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—AND—
Allied Branches of Study.

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CONTENTS.

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THE AMERICAN

Meteorological Journal.

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CURRENT NOTES.

THERE was a slight earthquake at Maryville, Tenn., on Sept. 14, at 3:30 P. M.—*Tennessee Crop Report.*

PROFESSOR L. CRULS has been appointed, by the Emperor, the director of the Observatory of Rio Janeiro, Brazil.

GEN. ALVORD, the retired paymaster general of the army, and known by his work on the tangencies of circles, etc., died Oct. 16, after a long illness of Bright's disease. He was the author of the work on *tangencies* in the Smithsonian Contributions about 1855, and also of the article in Johnson's Encyclopedia.

THE article in this number by Mr. L. A. Sherman, editor of the Port Huron *Times*, is in the line of a long series of investigations in various parts of the world and by various meteorologists looking toward the prediction of the weather for some days or weeks ahead. It is evident that, in the present state of the science, the most hopeful direction for this study is that of the motions of the general centers of high and low pressure, whose progress is real, but is so slow that the week or month is the best unit of time in which to express it.

ACCORDING to the *Rock County* (Minn.) *Herald* the tornado at last has a photograph. It would give us great pleasure to place this photograph before our readers, but, so far, we have been unable to obtain more definite information about it. The following is the *Herald's* account of it:

The *Herald* has received a fine cabinet photograph of the tornado which passed through Miner county, Dakota, August 28, taken at Howard, Dakota. This tornado, it will be remembered, was first discovered about 4 o'clock on a bright afternoon, when, with the exception of a few heavy banks of clouds, the sky was clear and the sun was shining pleasantly. Suddenly a monstrous funnel-shaped arm shot downward from one of the clouds and a moment later the tornado was formed and was moving slowly across the prairie, carrying destruction to everything in its course. The tornado remained in sight about two hours. The photograph is a great curiosity, and, undoubtedly, is the only photograph of a tornado ever taken.

THE following brief account of a "tidal wave," so-called, is from the *Monthly Weather Review* for July:

MILWAUKEE, WIS., July 24, 1884.—A tidal wave was felt to-day in the Menomonee and Milwaukee rivers. It was most noticeable at the "Straight Cut," as the entrance to the river is called, where the waters receded three feet, returning again in about fifteen minutes. Above the dam in the Milwaukee river, from two to three miles from the "Straight Cut," swimmers who were standing in shallow water were completely submerged by the returning waters.

This is probably called a *tidal* wave on the *lucus-a-non-lucendo* principle; that is, it is called tidal because it has no relation to what are generally called tides. Severe local storms were prevailing in that part of Wisconsin about this time, and the sudden rise of the water was probably due, in some way not fully settled, to a sudden change of pressure of air on that immediate neighborhood.

THE following *tornado axioms* are from J. F. Llewellyn, of Mexico, Mo.:

1. Tornadoes always rotate from right to left by way of north.
2. Tornadoes always move southwest to northeast, unless deflected by cause.
3. Hail always accompanies tornadoes, either immediately or within the area of storm attending clouds.
4. Severe lightning always accompanies tornadoes, present in tornado-cloud or accompanying clouds.
5. Tornado is a cloud that descends to earth.
6. The small end of funnel is destructive.
7. Funnel or taper end descends first.
8. Tornadoes occur during the passage of a low area.
9. Ninety-five per cent. occur southeast, south or southwest of low area.

THE Signal Service is purposing to organize observations on *atmospheric electricity*. The memorandum, of which we give the copy below, will show the field which the Service desires to occupy.

The following subjects are suggested for discussion, with a view to recommending proper observations and reports:

1. What unpublished records exist in the hands of electric lighting, telegraph, and telephone companies relative to ground currents and atmospheric or auroral influences?

2. What is the general experience on east-west, north-south, and other lines?

3. What records can be kept by managers of all lines without interfering with daily business?

4. What special observations can be made?

5. What special lines can be, perhaps, wholly devoted to the continuous record of the phenomena?

6. Do, or can, the noises and currents, as observed on telephone and telegraph lines, give information as to the location and future movement of a thunder-storm, aurora, rain, cold wave, etc.?

7. Are observations on buried lines, or those covered with metallic tubing, or double aerial lines specially desirable?

8. How can we best secure a complete daily electric survey of a given small portion of country, and a general survey of a larger region?

9. What is practicable in the way of securing a daily map of the distribution of atmospheric and terrestrial electric potentials?

10. Who will maintain self-recording electrometers?

WE learn from the St. Louis *Republican*, that, at a recent meeting of the Academy of Science of that city, Professor Nipher read a paper on the relation between the violence and duration of maximum rains.

His data were taken from Dr. Engelmann's observations, lasting over a period of forty-seven years. The violence of the rain is measured by the amount of rain falling per hour. Taking only the heaviest and longest rains during the above period of time, each rain is represented on a diagram by a point, if the duration and violence of the rain are taken as co-ordinates. It was found that rains of great violence lasted a comparatively short time, while gentle rains of a quarter of an inch per hour may possibly last a long time —as much as twenty hours in extreme cases. When all the points representing all the rains had been plotted on the diagram, it was

found that a curve passing through the outermost points, representing the rains where the greatest amount of water falls, is an equilateral hyperbola. This means that the duration of maximum rains is inversely proportional to the violence, or that the product of violence into duration is constant. This constant is the amount of water which may fall in a continuous rain, and is, for Dr. Engelmann's series of about half a century, about five inches. A rain of five inches per hour may last one hour; a rain of four inches per hour may last an hour and a quarter, and such a rain Dr. Engelmann observed. A rain of two and a half inches per hour may last two hours, and several such rains were observed. A rain of an inch per hour may last five hours. Each of these cases would be a five-inch rain. For a longer period of time than fifty years it is likely that greater rains than five inches may be observed. The same is to be said if observations are to be taken over a wider area of country. In fact, a rain of six inches in three hours occurred near Cuba, Mo., some years since. This would increase the value of the constant from five to six, but otherwise the relation will probably remain unchanged.

The importance of this law is very great in engineering, where the capacity of sewers, culverts and bridges must be such as to carry the water. A more general investigation which Prof. Nipher is now making will determine the relation between the violence, duration and frequency not only of maximum rains, but of all rains.

When this work is completed it will enable an engineer to construct the water-ways of bridges of such a capacity that they will probably stand a definite number of years before they are washed away. This number of years will be so determined that the interest on the invested capital during the probable life of the bridge will equal the possible damage when the destructive flood comes which the engineer determines shall destroy his work. The running expense of maintaining the bridge is then the least possible.

THE following account of the Huron tornado is from the *Dubuque* (Iowa) *Herald*, of September 2. It is sent us by Dr. A. Horr, who vouches for the reliability of the writer:

HURON, D. T., Aug. 28.—To-day has been very warm, and the sun was scorching in its heat. Everyone anticipated a thunder storm as the result, but none came. Instead of a thunder storm, I have had the opportunity of witnessing that wonderful sight, a water-spout on land, if a tornado may be so called. About half-

past three this afternoon, a single cloud was seen just north of the city. It was not of large extent, and no one thought that from it would be evolved one of nature's greatest phenomena. It looked so harmless and insignificant. When about two miles north of town, the dust underneath was seen in strange commotion; a number of little whirlwinds seemed gradually forming into one, while a long arm slowly reached down from the clouds to meet the approaching earth. This arm at first was indistinct in its contour, but rapidly shaped itself into the form of a funnel. The sun was shining brilliantly, and was not hid during the presence of the phenomenon, so that the great, whirling, seething, foaming pillar of cloud and earth seemed all the more weird aud unearthly, and it slowly made its way across the prairie, continually gathering force as it travelled. I had often wished to be able to witness one of these strange freaks of nature, but what I saw to-day I think half a mile is as near as I dare to apprrach. This cloud seemed about to make a clean sweep through the centre of the town, but, while the wind was directly from the north, the cloud moved to the south-east, just missing the town. We watched it for miles as it sped upon its wild way of ruin, wondering where it gained its mighty force and whither it carried its rage. It was a most beautiful sight, if one could for a moment forget its awfulness. I do not know as I can give you any idea of its appearance. I only know that a person seeing its approach has plenty of time to get out of the road if he is so minded. The great trouble is that at such times persons are not apt to think. About two miles from here one man had taken the precaution to dig a "cyclone cave." His wife saw the approach of the cloud and had plenty of time to reach the cave, but instead of doing so, tried to hold the door against the storm. The house and every thing it contained were torn and twisted to pieces, and the woman carried a hundred yards and more or less injured. And yet, to watch it at a short distance, one hardly realizes the force that is being used. During its passage there was no wind blowing, and it was only in the immediate track of the storm that there was any unusual disturbance of the atmosphere. The inverted cone that hung from the cloud did not seem to be in great disturbance, though in its centre was seen a lighter colored column which appeared to bubble and boil. As it crossed the river the water seemed to be carried bodily from the bed of the stream to the height of over a hundred feet. As it tore across the prairie everything in its way was sucked up into the capacious vortex. Heavy timber were as bits of paper

whirled on the summer breeze. Even iron bars were snapped in twain. Coming at the dead of night, such a storm-king would be a terrible thing. It is bound to take all that it touches. It would come without any warning, for in this case I failed to hear the "low, rumbling noise" which I had heard always accompanied a tornado. There was no storm of either wind or rain as a signal of danger. The heat of the day had caused a disturbance of the atmosphere, and it was only chance that directed the place of the inception of the storm. After it had passed here the cloud was seen to divide, and at one time there were as many as five of these peculiarly shaped clouds in sight at once. These would at times unite and again separate only to unite again. At the time of my writing to you we do not know the extent of the storm, but we know that wherever it has struck it has done more or less damage. I suppose there has never been a better chance to observe the formation and progress of a tornado than the chance I have had to-day, and such another will not be likely to present itself during a life time. A perfect summer day; not even the slightest mist; the air stirred up by a cooling zephyr; the broad prairie, over which one could look for miles without the smallest object to obstruct the view. * * * * I am sorry for the sake of science that photographs could not have been taken of the phenomenon at the different stages of formation. Though the rotary motion was so rapid, the progressive motion was quite slow until some time after it had passed this point. After that the storm moved twenty or thirty miles an hour. I wish that I were able to describe the wild and wonderful beauty of the scene; the strange cloud-form; the double cone with apexes joined; the funnel in whose center boiled what seemed like the terrible disturbance of the surface of the earth in the track of the storm; the buildings and timbers that seemed like play things. And then, but a very few feet away from all this, a bright summer day filled with sunshine and the singing of the birds. But it is a sight that cannot be described, but must be seen to be appreciated. I had only hoped to give some little idea of it as it appeared to me, and thought that some of your readers might feel some interest in the subject.

Yours truly,

W. F. Rupert.

LOCAL AND TOPICAL WEATHER CARDS.*

The chief difficulties attending weather prediction come from two sources. One is the individual behavior of certain storms; the other the individual conditions characteristic of certain stations.

The individual behavior of certain storms, such as their excessive violence, heavy winds, fast, slow or retrograde motion, or deviation from the expected trade—all these peculiarities may in time be learned, as the records of the various national weather services provide the student with enough examples of similar exceptions to allow the determination of the special conditions that accompany and govern them. This method of investigations has been applied with marked success by Professor Loomis and others, and is capable of great extension. But the investigation of the distribution of weather features in different parts of cyclonic areas, and the study of the special kinds of weather imposed upon certain single stations or groups of stations by passing storms has not yet been attempted formally or in detail so far as I can learn; though it is probable that the experts of the Signal Service are aware of many of its results from their great familiarity with our weather maps. It should be noticed that this line of study is essentially unlike that ordinarily employed in averaging the records of a meteorological station, in which the results give *climatic* factors and lose all sight of the control exerted by cyclonic disturbances on the weather changes. The importance of this control is now well recognized.

The first question asked in forecasting the weather is, where are the centres of high and low pressure? The passage of these cyclonic and anti-cyclonic conditions are the chief factors in determining a departure from the uniformity of seasonal climate to the irregularity of daily weather. In view of this, the weather cards that I wish to describe are constructed so as to exhibit weather phenomena graphically in their proper relation to the travelling areas of high and low pressure. This graphical method is simple enough, and is doubtless employed by many students of the subject, but it has not yet acquired its proper importance. To illustrate it, I may first describe the treatment of a subject that has already received

* This article contains the substance of a paper prepared for the recent meeting of the American Association in Philadelphia. It was not read, as the author could not attend the the meeting on the day to which it was assigned.

attention, namely, the construction of a card to show the course and velocity of the winds in a storm. The observations charted on a single Signal Service map are not numerous enough to give good results; but, by tracing the wind arrows from a number of different maps on a single sheet of tracing paper, a great number of observations can be accumulated in their proper attitude with respect to the centre of low pressure, and, on examining such a tracing or wind card, no doubt can remain as to the inward spiral course of storm winds, in spite of the preference for the circular theory still maintained by some nautical meteorologists. The further examination of such a card suggests two points for consideration: First, that the wind-direction should be registered more closely than by octants; second, that the somewhat abnormal velocity or direction belongs as much to certain stations as to certain storms; hence the necessity for the collection and study of such special conditions and their illustration by *local cards*, on which the winds or clouds or rains of a certain station are examined to discover their departure from the normal or average. Thus rain cards may be constructed for one station on the Atlantic coast, for another on one of the lakes, and for a third in the interior of the land, and it will clearly appear that the rainy area of the coast and lake stations extends much farther from the cyclonic centre than it does at the interior station. Another style of local card may collect the winds of Mount Washington, and such a one will show something of the value of this graphic method. It will be found that, when this lofty station is within the control of a cyclonic disturbance, its most violent winds will occur in the southwestern quadrant, and its greatest number of calms will stand in the north-northeast octant. Manifestly then, in calculating numerical averages, they should be made for these natural divisions, and not for arbitrary ones, such as the cardinal quadrants.

Still another subject for this treatment is found in the relation of areas of high pressure to those of low pressure. If two cards are prepared, one with the region of low pressure for its centre, and with the areas of high pressure traced in proper marginal altitude; the other with the high pressure in the centre and the low on the margin, it will be seen that the axes of the low pressure areas stand in no clearly defined relation to their direction from the high pressure, but generally maintain their ordinary northeastern elongation; while on the second card the longer diameters of the high pressure areas are very generally disposed so as to make circular arcs or tangents to such arcs about the low pressure centre. This gives a

simple graphic illustration of Mr. Ferrel's statement that high pressures or anti-cyclones are not individuals independent of cyclonic storms, but are really part of the latter; the ordinary anti-cyclone is merely part of the annulus of high pressure surrounding the cyclone and essential to it; the oval areas of high pressure shown on the maps are formed where the anti-cyclonic annuli of two adjacent cyclones overlap. Maps of larger areas than even our great territory are needed for this study.

The subject that has given me most satisfactory results on weather cards is the illustration of Lieut. Finley's recent studies on tornadoes. By tracing from his maps of tornadoes for the earlier months of this year, I have brought just about one hundred tornadoes on a single card, all in their proper relation to their parent cyclone. These violent local whirling tornadoes are seen to stand almost without exception in the south-southeastern octant of the cyclonic area, within the district occupied by the warm winds from the south, and distinctly east of the cooler winds from the west, at distances varying from 100 to 800 miles from the cyclonic centre. It is only near this centre that they escape from the limiting octant and fall beyond its eastern side. As the great cyclonic storm moves across the country, the octant in which the tornadoes may occur of course keeps pace with it, so that, as on Feb. 19 last, tornadoes were reported in Mississippi about noon, they appeared in Georgia about sunset, and late in the evening they had advanced into the Carolinas. This is clearly shown for the several separate cases on Lieut. Finley's maps, and is stated in somewhat different form in his recent publications; but it gains in distinctness by condensed illustration. A recent article by Mr. H. A Hazen, U. S. S. S., confirms this fact of distribution for a number of tornadoes of earlier date.

In view of so well marked a relation between tornadoes and the cyclones in which they spring up, I think it is difficult to withhold acceptance of Mr. Ferrel's deductive theory of tornado action, namely, that they are whirls established by the inversion of an unstable arrangement of the atmosphere, and that this unstable arrangement is especially apt to be produced on the southern side of our cyclonic storms, where the cooler westerly winds seem to rise and overflow the warmer moist winds from the south.

These examples by no means exhaust the many applications of the graphic method to the study of the weather; I can commend it as of much assistance in my own work, and I wish that many of our students may enter its inviting field. W. M. Davis.

WEATHER AREAS AND THEIR MOVEMENTS.

In presenting a few observations made by an amateur student in the budding science of meteorology, a short review of familiar facts may be excused as a preliminary illustration.

The movement of storms in a general direction from west to east, over the whole section of country embraced within the limits of the United States, east of the Rocky Mountains, is a fact well known to every intelligent citizen, and one that is constantly illustrated and set forth in the published records and predictions of the United States Signal Service. Storms, or areas of heat or cold, first making their appearance in Arizona, Colorado, or further north along the eastern base of the Rocky Mountains, sometimes far into British territory, move eastward, at times almost directly, but generally bearing either north or south, and frequently sweep through to the Atlantic coast. The exact course of such storms, the rapidity with which they will move, and the point at which they will spend their force and disappear, are things difficult to predict with accuracy; but as a rule they are recognized as continuous and individual phenomena, and their rate of movement is such that the Atlantic coast is reached within four or five days after their first appearance in the Rocky Mountain region.

The inquiry proposed to be made here, with a few observations as a foundation for an affirmative answer, is intended mainly to engage the attention of professional observers and students of meteorology. It is this: Are there natural laws which direct eastward across the continent, not only storms and areas of heat and cold that have a distinct individual development and rapid movement, but which also produce a recurrence of storms over a limited area which advances much more slowly, and may occupy many weeks in passing from the Rocky Mountains to the coast?

To illustrate: The fall of 1881 was a memorable one in Michigan on account of the terrible forest fires which raged in many sections, and especially in Huron and Sanilac counties. These fires occurred about the 5th of September, and in less than a week thereafter plenty of rain had fallen, and the remainder of the season was comparatively wet. The observations made were these: In the middle or latter part of July heavy rains began in Colorado, continuing at intervals for several days. Gradually this area of rain

moved eastward, crossing Kansas and Nebraska, passing into Iowa, Missouri, Illinois and Wisconsin, and prevailing in the vicinity of Chicago about the time the fires were raging in eastern Michigan. Throughout this entire section there had been a partial drouth until this area of rain brought relief in its onward course. A week after the forest fires plenty of rain had fallen throughout eastern Michigan, but for two weeks succeeding this time the New York City papers were complaining of the drouth in that section and expressing fears of a water famine. In the latter part of September the rains reached that city, but it was a week later before the drouth in eastern Massachusetts and Maine was reported relieved.

It is thus shown that an area of rain appeared in Colorado in July and moved quite steadily eastward, not as a continuous storm, but more as a series of local storms, or in some cases, perhaps, as typical cyclones, originating in the Rocky Mountain region and advancing across the continent, but discharging rain almost exclusively in the region where the apparent general storm or rain centre was at the time. The average rate of advance of this rain centre appears to have been from thirty to fifty miles a day.

In the spring of 1882 a friend who had made investments in Dakota returned from that territory, and remarked that the season there was nearly two weeks earlier than in Michigan. Central Dakota being nearly 200 miles further north than central Michigan, with a winter temperature averaging twenty to thirty degrees colder, this appeared almost incredible; but subsequent inquiries and observations, through the Signal Service reports, newspaper items, correspondence, and finally a personal visit to Dakota in the spring of 1884, have convinced me that this is generally the case. My observations show that winter usually begins in Dakota nearly or quite two weeks before it settles down upon Michigan, and that the area of settled winter weather moves steadily eastward. In the spring, again, there comes a time in Dakota when the "backbone" of winter appears to be suddenly broken, the snow melts rapidly, the surface of the soil thaws, and plowing can begin. This period in central Michigan is usually from ten days to two weeks later, and the movement of the spring area may be traced quite steadily eastward through the intervening territory.

Early in the spring of 1883 letters from Dakota brought the information that very heavy rains were falling there and that the prairies were in a terrible condition of mud and slush. At the same time there was a lack of rain in Michigan. Ten days to two

weeks later the area of rain had advanced into Illinois and Wisconsin, and in May it reached eastern Michigan, and for three weeks or more heavy local rains followed one another in such rapid succession that crops were nearly ruined, especially upon low, flat lands. This area of rain advanced eastward to the Atlantic coast, but I did not mark its course and movements with as much care as that of 1881. Later in the season drouth prevailed in Dakota, and this area followed the previous area of rain, about a month behind, through to the coast.

Having become interested in these eastward movements of weather areas, I ventured, in the latter part of January, 1884, to make and publish a prediction based upon the theory indicated, and had the gratification of seeing it fulfilled. The circumstances were these: January, 1884, in Michigan, was a steadily severe winter month. Noticing the temperature at Bismarck and other points in Dakota, I found that each cold wave there averaged thirty degrees colder than in central Michigan. About the middle of the month it was observed that the temperature frequently rose in Dakota without any subsequent response in Michigan, indicating that an area of comparative warmth had developed, or reached there from some point further west. This warmth was not sufficient to cause a thaw, but taking the average, and adding to it the thirty degrees difference between Dakota winter temperature and that of Michigan, it would bring a break-up here. Watching this area as carefully as the Signal Service reports and letters from special correspondents enabled me to do, I found that within a week the area of warmth had advanced to St. Paul, and I then (about January 25th) published a paragraph saying that there were indications warranting the prediction that February would be a comparatively mild and open month in Michigan.

My calculations proved to be well founded. Early in February, I think about the 3d, the area of warmth reached eastern Michigan, bringing the first thaw since New Years, and the mild weather, with occasional snow storms and frequent thaws, lasted nearly the entire month. On one day the temperature reached sixty, which was just thirty degrees warmer than the highest I had noticed in Dakota when the area of comparative warmth prevailed in that section.

Early in February I noticed again that another area of severe cold prevailed in Dakota, and about the 20th of the month, having watched its advance into Minnesota, predicted its arrival in eastern

Michigan during the last week in February, and its continuance for two or three weeks, which forecast was exactly fulfilled.

The subsequent spring break-up began in Dakota about the 1st of March, but did not reach Michigan until two or three weeks later.

The rain areas of the present season I have not been able to trace with like exactness. During July and August there was an apparent advance of a rain area from northern Dakota across Minnesota and northern Wisconsin and Michigan, and possibly into Canada, but central and southern Michigan received but little of it.

The observations here set forth clearly indicate that there is frequently, if not continuously, a steady and comparatively slow advance of weather areas from west to east, in the latitude of Michigan at least, if not further north and south. Is it not possible that careful observations and records may in time make apparent the natural laws which govern these movements, and enable our weather prognosticators in many cases to tell us some days or weeks in advance what the general character of the weather is likely to be? If this could be done it would prove of immense practical value to agriculture, and to very many other branches of industry throughout the country.

LOREN A. SHERMAN.

RECENT DISCOVERY OF THE TRUE SOURCE OF THE MISSISSIPPI RIVER.

By CAPTAIN WILLARD GLAZIER.

CHAPTER IV.

EXPLORATION AND DISCOVERY.

Upon the return of Che-no-wa-ge-sic and other Indians a council was held, and my object stated to them. They were requested to delineate maps of the country, and to furnish an interpreter, guides and canoes. Che-no-wa-ge-sic said: "My brother, the country you are going to visit is my hunting ground. I have hunted there many years, and planted corn on the shores of Lake Itasca. My father, now an old man, remembers the first white chief who came to look for the source of the Great River. But, my brother, no white man has yet seen the head of the Father of Waters. I will myself furnish the maps you have called for, and will guide you onward. There are many lakes and rivers in the way, but the waters are favorable. I will talk with my friends about the canoes, and see

who will step forward to furnish them. My own canoe shall be one of the number."

But a few hours were required to complete the maps, and on the following morning, July seventeenth, three Chippewas, including Che-no-wa-ge-sic, brought each a canoe and laid it down on the shore of the lake. One other Chippewa expressed a willingness to accompany us to the mouth of the Kabekanka River. These, with Mr. Paine, my brother and myself, and our luggage, were distributed equally in the three canoes secured by Che-no-wa-ge-sic.

A large number of Indians, most of whom were the relatives and friends of our guides, assembled near the point from which we had decided to launch. The wind blew briskly from the North, making the surface of the lake quite rough for canoe navigation, and it was with some distrust that we stepped gingerly into the canoes and took our appointed positions at the imminent risk of capsizing them by our awkwardness. The Indian guides took their places at the stern, with instructions to act as pilots. Rev. Mr. Benedict, who accompanied me to the place of embarkation, now came down to the water's edge, and, seizing the stern of my canoe, gave us the launch. A waving of hats by way of farewell to our friends at the Post who had come down to the shore to see us off, and our birchen fleet got under way and glided out into the deep water of the lake, propelled by the lusty strokes of our voyagers, and our own faint attempts in the same direction.

An hour's vigorous paddling took us across the arm of the lake on which the Agency is situated, and then a short portage over a point of land brought us to a much larger body of water, where the wind and the waves had a sweep of from fifteen to twenty miles. We coasted along the shore for some distance, and then headed directly across the lake for the mouth of the Kabekanka River. The waves ran high, and our canoes rose lightly on them, sinking again with a swash into the trough, and splashing the water over our bows. Gradually we became somewhat accustomed to this, and gained sufficient confidence to gaze around at the broad expanse of lake and sniff the fresh and invigorating breeze which at the outset had caused us so much uneasiness.

Between two and three hours of persistent work with our paddles brought us to an inlet into which the Kabekanka empties; and, forcing our way through the rushes with which the mouth is filled, we ascended the stream, and at about eleven o'clock came upon a small lake caused by an expansion of the river.

EMBARKING FOR THE HEAD WATERS OF THE MISSISSIPPI.

Paddling to the upper end of it, we landed, and, building a fire, had our first meal in the open air. Re-embarking, we continued our course up the Kabekanka. As we ascended, the river became narrower and swifter, and the wild rice which at first filled its bed gave place to snags and driftwood, through which it was almost impossible to force our canoes. We had nearly reached the conclusion that we could go no farther in the canoes, when we came to what seemed to be a pond of still water filled with rushes. This pond, we soon discovered, was the outlet of a large and beautiful lake not less than seven miles long, into whose tranquil waters we burst with a shout of gladness.

The sun was now well down towards the western horizon, and the question of supper and a camp ground began to agitate the minds of my companions. Continuing our course, we paddled slowly up the lake, trolling for fish as we prospected for a suitable spot on which to pitch our tents. A model camp-ground was soon located on a bluff near the lake, wooded with Norway pines, and sloping rather abruptly to the water.

Our trolling was rewarded with a fine mess of pickerel; so we landed at once, and the fire of our first camp was soon crackling merrily. The guides prepared supper, while my brother and Paine pitched tents and swung their hammocks among the pines.

The zest with which we relished our supper of fish, enhanced by the addition of canned dainties from the civilized world, can readily be imagined; and as we smoked the pipe of contentment under the shelter of the grand old pines, we felt that the hardships of our voyage had been greatly magnified. After discussing the events of the day, we retired to our tents, or rather were driven thither by clouds of mosquitos which, ignoring the smoke of our camp-fire, began their onslaughts as soon as the light of day disappeared. Paine attempted to find peaceful slumber in his hammock, but was soon sung and stung into a hasty retreat to the tent which George had, with some care, made mosquito-proof. A grand mosquito serenade was now inaugurated, which continued without interruption until the sun appeared above the lake. Fortunate, indeed, for us that we were beyond their reach, as the Minnesota mosquitos demand nothing less than blood for their singing.

We struck tents at break of day on the morning of July eighteenth, and, launching our canoes, paddled to the upper end of the lake, where we disembarked and had breakfast.

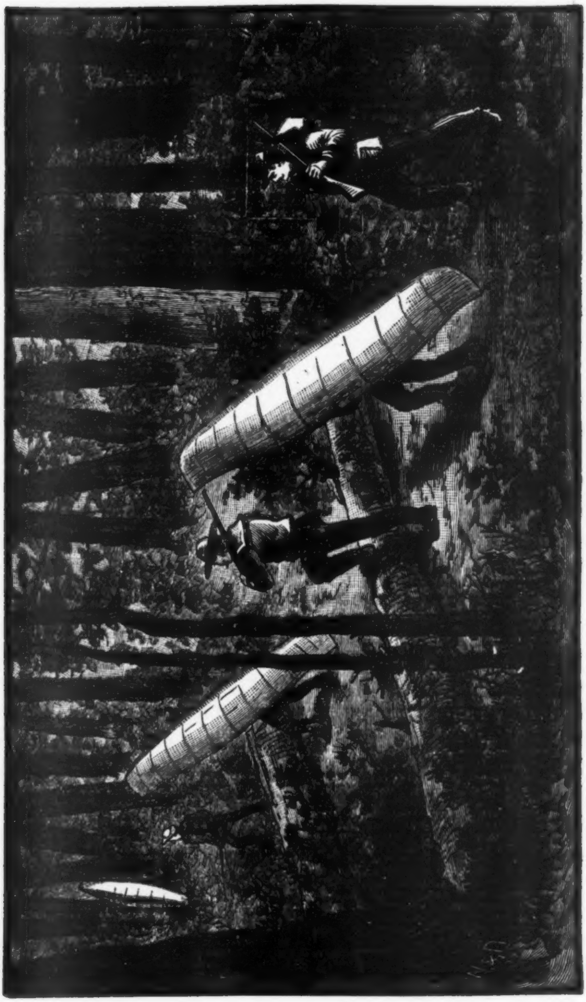
Learning from Che-no-wa-ge-sic that the Indians had no name for this beautiful body of water, I designated it "Garfield" in honor of our president, James Abram Garfield.

At the head of Lake Garfield we reached the terminus of uninterrupted water communication, and I was informed by my guides that a portage of between two and three miles lay before us. In blissful ignorance of what a portage really was, this announcement had no terror for us, and we gayly packed our traps into convenient bundles for carrying. The Indians had, in the meantime, prepared packs for themselves weighing upwards of a hundred pounds, which they rolled in their blankets and secured with a strap which was passed over the forehead, allowing the pack to rest on their shoulders. On top of this they each placed a canoe, bottom upwards, resting it on the pack by means of a cross-bar, and thus loaded started through what seemed to us a trackless forest.

Following the lead of our guides, we shouldered our guns and kept up as best we could, for their pace at times increased almost to a run. The undergrowth was so dense that we could not see where to put our feet, and were only guided by the white bottoms of the canoes in front of us. On we went, up hill and down, over logs and through bogs, barking our shins, scratching our faces on the rough limbs, panting for breath, the perspiration flowing in rivulets from every pore, and bitten by countless mosquitos, until it seemed that we could proceed no further; still the guides trotted along with their burdens, showing not the least sign of fatigue. At last, however, as we were about to drop from sheer exhaustion, the guides halted and deposited packs and canoes on the ground, rolled out from under them, and, after a smile at us, began picking blue berries which were found in great abundance near by. As for myself and white companions, we threw ourselves down almost breathless, without even energy enough to fight the mosquitos.

Eager to reach higher ground, we again shouldered our luggage, and were soon on the trail following in the footsteps of Che-no-wa-ge-sic. Rushing rapidly forward, we gained the top of a hill at eleven o'clock, where we halted for rest and refreshment. Being out of mosquito range in this elevated region, we spent a few hours very pleasantly while the guides served dinner and carried the canoes and luggage forward to the next lake.

As soon as we were sufficiently recovered from the fatigues of the morning, we returned to the trail which had been our line of march



MAKING A PORTAGE.

since leaving Lake Garfield. On descending the hill we were again beset by clouds of mosquitos—in short, there were

> Mosquitos to right of us,
> Mosquitos to left of us,
> Mosquitos all around us,
> Singing and stinging.

A few rods from the foot of the hill we came to a lake, the first of a chain of five lakes having for their outlet a small river known to the Indians as the Gabekanazeba, which in Chippewa means portage.

Once more on the water, we pulled through three lakes alternated by as many portages, and at night encamped on the shore of a fourth lake. On the following morning we were astir at dawn. Had breakfast at sunrise, and by seven o'clock were again in our canoes paddling toward Itasca. The fifth and last of the portage chain was reached at ten o'clock. Learning from my guides that these beautiful lakes had never before, to their knowledge, been seen by white men, I named them successively Bayard, Stoneman, Pleasanton, Custer and Kilpatrick, as a tribute to the favorite Union cavalry leaders of the late war—patriot soldiers who deserve well of their country, whose call I have often responded to in the campaigns of the Army of the Potomac.

After crossing Lake Kilpatrick another string of portages was encountered, aggregating for the day no less than eight, alternating with as many lakes, all small, some of them being little more than ponds, except three which terminate the portage chain. Continuing my cavalry column, I named these three lakes, which are fine bodies of water, successively Gregg, Davies and Sheridan; after General Gregg of Pennsylvania, under whom I served for a short period during the Gettysburg campaign; General Davies of New York, on whose recommendation I received my first commission, and who rose from the rank of a major in my old regiment, the Harris Light Cavalry, to that of major-general and the command of the Cavalry Corps under Grant; and after that true knight of cavalry, Lieut.-General Philip Henry Sheridan, hero of Cedar Creek and Five Forks.

Towards evening we reached the largest sheet of water between Leech Lake and Lake Itasca, the Indian name of which translated is Blue Snake Lake. We crossed this lake at a point where its width is about five miles, and carried our canoes to the summit of a narrow strip of land which separates it from another lake of less than half its size. Here, as elsewhere during our voyage through Minnesota, we found blue berries in great abundance, and it was

with much difficulty that I persuaded my companions to perform their duties before they had satisfied their cravings for this delicious fruit.

As soon as we had decided upon a camp ground, Paine and Che-no-wa-ge-sic pitched tents, my brother launched his canoe in quest of fish, while Moses Lagard, the interpreter, and his brother Sebatise prepared supper.

After attending to the duties of the camp, I went down to the lake which we had just crossed, and strolled along the white sand beach of its western shore. Tracks of the wolf and deer were frequently seen in the sand—the first evidences of wild game in our voyage. Retracing my steps I met George, who was just returning with a fine mess of bass, which, with corned beef and a small quantity of bread supplied by Moses, afforded us an excellent meal, which all were fully prepared to enjoy.

The mosquitos, our inveterate enemies, did not neglect us here. On the contrary, they began their nightly orgies upon the going-down of the sun; whereupon we dampened the ardor of their spirits in a measure by throwing a cordon of subdued fires entirely around our little camp at intervals of from ten to fifteen feet. We now enjoyed the alternative of enduring the smoke within the camp or fighting the mosquitos without.

Next morning we had breakfast at five o'clock, struck tents at six, and a few moments later launched our canoes upon the beautiful lake which is a companion to the one we had crossed the previous evening. The first and largest of these lakes I called George, after my brother George of Chicago, who accompanied me from Brainerd to the source of the Mississippi and from thence to Lacrosse in my descent of the river; the other I named Paine, after my constant companion, Barrett Channing Paine of Indianapolis, Indiana, who stood at its head, drank from its farthest springs, and subsequently shared the privations, dangers and triumphs of my canoe voyage down the Great River to the sea.

Crossing Lake Paine, we made another portage of half a mile, which brought us to a small river known among the Chippewas as the Naiwa. Che-no-wa-ge-sic explained that the Naiwa was a stream of considerable length, having its origin in a lake which is infested with snakes, to which its name has reference.

We descended the Naiwa between five and six miles, and then portaged westward to another small river, with which it unites a few miles below. We found the new stream more decidedly marshy

in the character of its shores, but not presenting in its plants or trees anything to distinguish it particularly from the Naiwa. The water is still and pond-like. It presents some small areas of wild rice, and appears to be a favorite resort for the duck and teal, who frequently rose up before us, and were aroused again and again by our progress.

Four hours of vigorous paddling brought us to the foot of a lake where we halted a few moments to survey. It exhibits a broad border of aquatic plants, with somewhat blackish waters. It is the recipient of two brooks, and may be regarded as the source of this fork of the Mississippi.

While passing through this lake we came upon several broods of mallard ducks, and my companions were not slow in testing their fowling pieces. A broadside from rifle, shot-gun and revolver was simultaneously opened, but, much to the chagrin of those who fired, only one duck was killed. The water-fowl encountered here seem to exult in their seclusion, and evinced the infrequency of intrusion by flying a short distance and alighting within range of our fire-arms.

We were twenty minutes in passing through the lake, which I named Elvira, in memory of my oldest sister. On reaching its southern end we entered one of the brooks. It possessed no perceptible current, and was filled with broad-leaved plants, rushes and swamp-grass. After paddling up this inlet about forty rods we appeared to be involved in a morass where it seemed impracticable to either make the land or proceed further by water. In this we were not mistaken. Che-no-wa-ge-sic soon pushed his canoe into the rushes and exclaimed: "*Oma mikunna*"—here is the portage. A man who is called on for the first time to debark in such a place will cast about for some dry spot to put his feet upon. No such spot, however, existed here. We stepped into rather warm pond water, with a miry bottom. After wading a hundred yards or more the soil became firm, and we began to ascend a slight elevation where the growth partakes more of the character of a forest. Traces of a path appeared here, and we suddenly entered an opening which afforded an eligible place for landing. Remains of former fires, the bones of birds, and scattered camp-poles, proved it to be a spot which had previously been occupied by the Indians.

Having followed out this branch of the Mississippi to its source, it may be observed that its existence as a separate river has hitherto been unknown in our geography. None of the maps indicate the ultimate separation of the Mississippi above Lake Bemidji into two

forks. It is a matter of much surprise that this river should have been kept so long in darkness, especially when we consider the fact that its presence was known to white men nearly fifty years ago. It was ascended in 1832 by Schoolcraft in his memorable voyage to Lake Itasca, who omitted to bestow a name. I christened it Schoolcraft River, as a tribute to its discoverer, who, though he failed to reach the goal of his explorations, rendered valuable service in the department of geography.

The sun was rapidly sinking behind the hills as we reached dry land, and being nearly exhausted by the portages of the day, and in want of refreshment, a camp-ground was at once decided upon, and preparations for supper begun.

It was at this point that we first discovered a deficiency in our supply of rations. At the outset we counted largely upon our fire-arms and fishing-tackle to reinforce our bacon and canned meats; but thus far, however, but one duck had been killed, and, as compared with our former estimates, but few fish had been lured from their native element. Then, as a climax to our embarrassments, my brother had the misfortune to lose the trolling hooks and nearly all the ammunition while passing through a bog in the last portage. Much powder and ball had also been consumed by my white companions, who sought to test their marksmanship upon every animate object along our line of march. A strict adherence to truth compels me to say that up to this time, much to their chagrin, the entire outlay of ammunition resulted in caging but the one duck previously alluded to.

We were now not less than seven days from the trading post at Cass Lake, and with only about two days' rations. Not even an Indian could be found in that lonely region with whom to parley for food. It may be safely concluded that before we retired to our tents that night we looked our project squarely in the face. Despatch in our onward progress was earnestly recommended. An equal distribution of rations, and the most rigid economy in the use of ammunition, was also insisted upon.

A dense fog which completely enveloped the swamp in our immediate front prevented our getting upon the trail until seven o'clock in the morning of July thirty-first, and it was even then impossible to distinguish objects at a distance of twenty yards. While waiting for the fog to raise, a small flock of pigeons dropped into the tops of some tall pines near by. George and Paine were inclined to observe their usual practice of discharging their fire-arms; but,

as I considered the pigeons out of range, I reminded them that no more ammunition could be thrown away upon uncertainties.

The portage from the eastern to the western branch of the Mississippi is six miles. Beginning in a marsh, it soon rises into a little elevation covered with a growth of cedar, spruce, white pine and tamarack. Then plunges into a swamp matted with fallen trees, obscured by moss. From the swamp the trail emerges upon dry ground, from whence it soon ascends an elevation of oceanic sand, having boulders, and bearing pines. There is then another descent and another elevation. In short, this portage carried us over a series of diluvial sand ridges which form the height of land between the Mississippi and Red River of the North. It may be said that these ridges constitute the table land between the waters of Hudson's Bay and the Gulf of Mexico, and give rise to the remotest tributaries of the river Saint Louis, which through Lake Superior and its connecting chain may be considered as furnishing the head-waters of the Saint Lawrence. This is unquestionably the highest land of North America between the Alleghenies and Rocky mountains.

In crossing this highland my Indian guide, Che-no-wa-ge-sic, led the way, carrying as usual one of the canoes as his portion of the burden. The others followed in Indian file, each bearing a canoe or its equivalent in luggage. As soon as all were on the trail we moved rapidly forward, halting occasionally for rest. The Chippewas denominate each of these stops *opugidjewinon*, or a place of putting down the burden. Thirteen of these rests were given by Che-no-wa-ge-sic as the length of the portage. The trail is often obscured by a dense undergrowth, and requires the precision of an Indian eye to detect it. Even the guide was sometimes disconcerted, and went forward to explore. About midway of the portage we came to a small lake, into which we quickly put the canoes and pulled for the opposite shore. The route beyond was more obstructed by underbrush. To avoid this we waded through the margins of a couple of ponds, near which we observed old camp-poles, indicating former journeys by the Indians.

The weather was much warmer than I had anticipated for this elevated region, and not favorable to much activity in bird or beast. Several flocks of pigeons and other birds common to northern latitudes were frequently observed. Tracks of deer were numerous in the marshes skirting the ponds, but traveling without the precautions required in hunting, we had no opportunity of seeing this animal in the high grounds. Ripe strawberries were found on the

hillsides, and a very small species of the raspberry, with fruit, was brought to me by Che-no-wa-ge-sic at one of the resting-places. The student of botany would consider the plants few and of little consequence.

On turning out of a thicket at the foot of the last elevation, between three and four o'clock in the afternoon, our longing eyes rested upon the waters of Lake Itasca. A few moments later we were floating on its placid bosom, and, after a pull of between two and three miles, reached Schoolcraft's Island. This island derives its name from Henry Rowe Schoolcraft, who discovered Itasca in 1832, and located it as the source of the Mississippi.

Hitherto the claim of Schoolcraft has been unquestioned, and for half a century Lake Itasca has enjoyed the honor of standing at the head of the Father of Waters. The island is about three quarters of an acre in extent, and so densely studded with undergrowth that we experienced much difficulty in clearing a place for our tents. We found here but two or three trees worthy of notice, the most prominent of which was a tall gray pine, and on this Paine blazed our names and the date of our encampment.

Itasca is in every respect a beautiful lake, between five and six miles in length, and from one-fourth to three-fourths of a mile in width. It has three arms—one to the southeast, three miles long; one extending to the southwest from the island; and one reaching northward to the outlet two and a half miles. Its greatest length is from southeast to northwest. I asked Che-no-wa-ge-sic the Chippewa name of this lake, and he replied "Omushkos," which means Elk. Schoolcraft tells us that the word Itasca is derived from the mythological and necromantic notions of the Chippewas concerning the origin and mutations of the country.

We were in no condition to enjoy our delightful surroundings at this point, in consequence of the reduced state of our supplies. Determined upon a thorough exploration of the region adjacent to Lake Itasca, we were now confronted with a subject for serious consideration. We were at least six days from the nearest post of relief, and entirely out of rations, with the exception of a small piece of bacon and a few pounds of flour. The trolling-hooks were lost, and there were but sixty five rounds of ammunition left. In this dilemma my white companions favored exploration. The Indians preferred an immediate descent of the river.

(*To be continued.*)

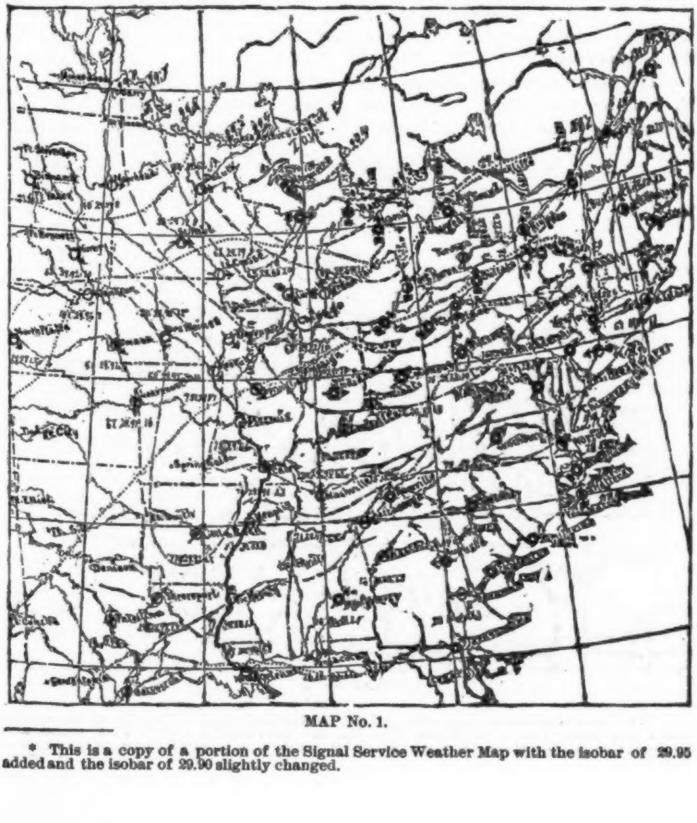
THE THUNDER-SQUALLS OF JULY 5TH.

I.—Description.

July 4th and 5th of the present year were characterized by severe and destructive thunder-storms in the United States. On the 4th they were mostly confined to the vicinity of the Lower Missouri and Upper Mississippi Valleys, three small tornadoes and numerous hailstorms being reported from Iowa.

On the 5th they covered a large portion of the country east of the Mississippi River. A few destructive local storms were reported from the southern states on the 6th.

These local storms were the accompaniment of an area of low pressure which on the morning of the 4th covered nearly the whole of the United States. Within this low area were three well defined centers of disturbance, one central in Dakotah, a second in or just north of northern Texas, and a third in southern Michigan. On the morning of the 5th all these centers had combined forming one of unusually low pressure central in the Upper Lake Region as will be seen from the accompanying map No. 1*, which shows the weather condition at 6:08



MAP No. 1.

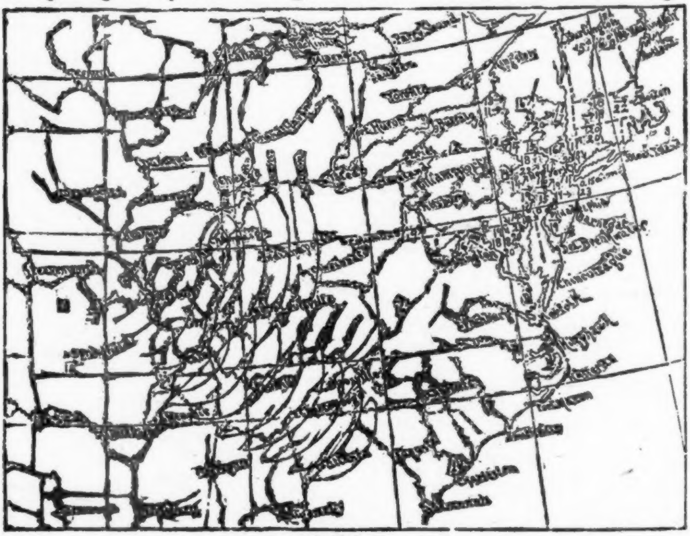
* This is a copy of a portion of the Signal Service Weather Map with the isobar of 29.95 added and the isobar of 29.90 slightly changed.

A. M., ninetieth meridian standard time, to which all the times given in this article have been reduced. The cyclonic center remained in this region all day, slowly moving eastward, and by the morning of the 6th had entered Canada.

Two extensive and severe thunder-squalls occurred on the 5th, one in the morning and the other during the afternoon and evening. Besides these, two smaller squalls can be traced, one apparently originating in western Missouri about midnight of the 4–5th and disappearing in southern Illinois about daybreak, the other apparently originating about 6 P. M. in southwestern Missouri, passing across northern Arkansas and disappearing in western Tennessee and northern Mississippi about midnight of the 5–6th. All day of the 5th thunder-storms were forming and disappearing in the eastern states, but they seem to have been very local phenomena, and no general movement can be traced. The positions and time that thunder was first heard accompanying these storms are given on map No. 2 by the figures which show the time according to the twenty-four hour system. The number 18, for instance, means 6 P. M. The small arrows point in the direction toward which these storms appeared to move.

Information concerning the extensive morning squall is obtained from reports from fifteen stations, mostly in Indiana.* They are not all in perfect agreement, but the bulk of the stations give the position of the front of the area of rainfall accompanying the squall at the beginning of each hour about as represented by the lines on map 2.

The station reporting the earliest time of its occurrence is Newport, Ind., near the boundary line between Indiana and Illinois. This station gives the time of its beginning shortly before midnight of the 4–5th. While in the main having a



MAP No. 2.

* This information as well as information concerning the thunder-storms of the eastern states was obtained from the Signal Office through the kindness of Prof. H. A. Hazen, who copied for me the reports on the Signal Service thunder-storm postals concerning the storm of July 5.

motion toward the west, it seems to have spread backward as well as forward, for the observer at Mattoon, Ill., located at the position of the star on the map, states that the storm begun at 1 A. M., coming from the northeast. The main movement of the storm, however, was from the west, with an average velocity of about fifty miles per hour. During the first two hours of the squall's existence the rainfall near the center was very heavy, Jamestown, Ind., reporting as much as three inches. After about 2 A. M. the rainfall in the squall decreased until it finally became extinct. The remarks given by the observers regarding the squall were as foltows:—"Heavy storm all around, "Heavy storm," "High wind," etc. The following extract taken from the July *Monthly Weather Review*, U. S. A., after the above was written, shows that the storm was more extensive in Illinois than represented on the map: "St. Louis, Mo., 6th: Reports from Christian, Macon, Sangamon and Shelby counties, and from other localities in central Illinois, state that a very severe and destructive wind-storm occurred during the night of the 4–5th. In the vicinity of Illiopolis, Sangamon county, several farm houses were badly damaged, and also wheat shocks and growing corn, the latter being beaten to the ground. The losses sustained in Sangamon county are estimated at more than $100,000. Numerous dwellings in Macon county were wrecked, the damage in that county being estimated at $200,000."

The smaller morning squall in Missouri seems to have begun and ended about the same time as the larger, and some severe local storms were reported to have occurred about the same time in Maryland. Want of space forbids the giving of the information obtained concerning the smaller squalls. They each traveled, however, in the neighborhood of fifty miles per hour, and neither were destructive. It is interesting to note that the reflection of lightning from both the morning squalls was noticed at St. Louis.

About midday began the formation of probably the severest squall of all, and fortunately it can be described with considerable accuracy, since it passed over a region in which there was a large number of "voluntary observers." The description given in this article is based on reports from about sixty stations concerning it, five in Missouri, four in southern Illinois, one in Indiana, one in Arkansas, forty-two in Tennessee, three in northern Alabama, one in North Carolina and one in Georgia, besides reports from a number of stations in all these sections, which, by reporting the non-occurrence of the squall, enabled its limits to be determined. The total reports at hand number over seventy. Unfortunately not a report concerning it was to be obtained from Kentucky. The willingness the most of the observers expressed, to do anything they could to assist in the investigation of the phenomenon, is extremely gratifying. These men are nobly giving a good portion of their time to gathering weather statistics, and are thus materially assisting in obtaining the material out of which is to be erected the science of meteorology, as yet but dimly outlined.

Before describing the squall, it is well to review the conditions under which it occurred. As will be seen from map No. 1, at 6:08 A. M., a cyclonic system of winds, whose center was in the Upper Lake Rigion, covered the whole of the country east of the Mississippi River, the pressure in which was below the normal of such systems. The most interesting point however was the peculiar bending of the isobars just west of the Mississippi where the squall originated. The appearance is as if a spur of high pressure projected into the region of low, causing the isobars between it and the cyclonic center to be crowded together, and as if just in front of this a spur of low pressure projected into the region of high pressure, causing the lines between its outer edge and the cyclonic center to be less

crowded than the average. This condition seems to have continued all day, and if the reader will suppose that while the cyclonic center remained nearly stationary the isobars of 29.95 running in the vicinity of Leavenworth pushed rapidly to the southeast carrying the spur or trough of low pressure before it, he will have a fair idea of the positions of the isobars all day. The peculiar bending of the isobars proceeding and accompanying the squall has been noticed before. It was very prominent in the squall which occurred in Germany on Aug. 9, 1881, investigated by Herr Koppen, and also in the squall which occurred in Germany on May 13, 1884, investigated by Dr. Assman.

In the September number of *Das Wetter*, it is stated by Dr. Ciro Ferrari, of Rome, that this is a common, if not constant. accompaniment of thunder-storms. From observations made during a large number of thunder-storms, both by himself and by observers throughout Europe, studied both synoptically and by single stations he derives the following law: "Every thunder-storm is connected with a small depression in the rear of which it is found. Generally there follows behind the depression a ridge of high pressure."*

The squall under consideration followed this law in originating and remaining between these spurs of high and low pressure.

The 5th was an unusually hot day throughout the whole of the United States east of the Mississippi. A large number of stations reported the maximum temperature of the month on this day. The temperature in the Ohio Valley and Tennessee averaged about 90° in the hottest part of the day. 96° from Memphis is the highest reported. The dew points in the same region averaged about 76°. None of the reports at hand (about six) concerning this, show a dew point during the day greater than 80°, or less than 71°, before the passage of the squall. The highest dew point was reached at all the stations just before the passage of the squall, and at none was less than 75°. This high dew point, with scarcely any wind, rendered it very sultry before the passage of the squall. The observer at Centerville, Mo., gives the following observations of temperature:

Time.	Thermometer in shade.	Ther. bulb in ground 3 in. deep.	Ther. on surface of ground.	Remarks.
Min. read at sunrise...	68°		74°	"These being the highest ground temperatures of the season, I think may be taken as the standard of high temperature for summer." M. McKenzie.
7 a. m.	81°	77°	92°	
Noon	94°	90°	100°	
Sunset............	65°	76°	66°	

The first information concerning the squall is obtained from Chamois, Mo. The observer reports that a thunder-storm began at 12:15, P. M. The observer at Glasgow, about 70 or 80 miles to the north-west of here, reports that no thunder-storm occurred at that place, though lightning was visible in the south-west from one to three P. M. The observer at Sedalia, about the same distance to the west of Chamois, reports that no thunder-storm occurred there at that time of day, though there was a light shower at 12:50 P. M. It seems evident then, that right here in central Missouri, just north of the Missouri River, near the 92° meredian, was the birth-place of the squall. The observer at Chamois writes: "In referring to my record, I find July 5 was a strange day. Up to the 5th there had been very warm winds, mostly south and south-east. At 2 A. M. constant lightning in the

* Literally "a heaping up of pressure."

south-west. Cool north-west and west winds during the day. At 12:15 P. M., heavy thunder in the north-west, and later as heavy thunder and vivid lightning as I ever saw, with light showers out of small streaky looking clouds, with little hail at 2:15 P. M. Showery from 12:15 to 2:20 P. M." St. Louis reports a shower from 1:20 to 1:25 P. M., no doubt the edge of this storm. The next reports are from Centerville and Ironton, Mo., and Swanwick, Ill., all of which report the beginning of the thunder-storm about 2:30 P. M. Up to this time the wind accompanying the squall was no greater than that usually accompanying thunder-storms, but by 3 P. M. it had developed into a gale. The lines drawn on map No. II, across south-eastern Missouri, show the position of the front of the thunder-storm at the hours given. The lines drawn after this, represented by the curved lines crossing Tennessee, show the position of the front of the hurricane-like-winds at the beginning of each hour. The determination of this admits of more precision than that of any phenomena connected with the squall.

An observer, busily engaged in the house, might not notice distant thunder until it was right upon him, or even might not notice the rainfall until sometime after its beginning; but the winds accompanied by a loud roar, and a clatter of small objects, bursting as they did upon the observer, just previously immersed in a quiet or almost quiet atmosphere, could hardly have failed to attract the attention, and if the time was noted, it could not have been far wrong if the time-piece was right, and since the railroads have adopted the custom of sending the time to all their stations by telegraph, the observers generally keep pretty accurate time. It is rendered apparent in this case by the remarkable agreement of the stations in the succession of occurrence of the phenomena and of the neighboring stations with one another.

Some few stations give the time of the arrival of the winds a little earlier than stations just west of them, but there were in Tennessee only about eight of these out of forty-two, and the greatest variation was but little over half an hour from the correct time as determined from the bulk of the stations. With these exceptions, the reports all unite in showing that the front of the squall was the almost perfect curve represented by the lines on the map. Stations in southern Illinois and Indiana enable the northern boundary and time of occurrence of the squall to be determined with accuracy; but between 7 and 9 P. M. these were determined approximately by extending the lines as they left the state of Tennessee.

At 10 and 11 P. M., the northern boundary was within the limits of observing stations again. and was determined by reports from these. Reports were received from stations all along the southern margin of its track after 5 P. M., and its limits must have been approximately, as given on the map.

The last station from which information has been received concerning it, is Atlanta, Ga., which station the wind seems to have reached about 10:30 P. M., with but slightly abated violence, lasting till near midnight. The wind averaged 37 miles per hour, in 15 minute intervals, but in gusts it reached a velocity of 50 miles per hour. The rainfall accompanying it at this station, however, was inappreciable.

Augusta and stations to the east report that nothing of it was observed, so that this vicinity must have witnessed its death struggle. The squall thus traveled from central Missouri to central Georgia in a little over 10 hours, from which is obtained the approximate average velocity of 53 miles per hour. Its greatest velocity seems to have been about 6 P. M. Its velocity of motion while in Tennessee was determined from the position of lines drawn on a large map of Tennessee representing the position of the storm front every half hour, and was about as

follows: ——— from 5 to 6 P. M., 65 miles; 6 to 7 P. M., 57 miles; 7 to 8 P. M., 49 miles: 8 to 9 P. M., 43 miles.

The following reports give data by which the width of the area of high and destructive winds can be determined: Cairo—"Gale ended 4:40 P. M." Allowing for a motion of the rear end of the gale, according to the known velocity of the squall, it places it to the east of Cairo at 5 P. M. A line drawn through this point, so as to connect with the ends of the line representing the front of the squall, seems to be the diameter of a semicircular area. Trenton, Gibson county, Tenn., reports that the "wind ceased" at 6:30 P. M. Again allowing for a motion of the wind to 7 P. M., and drawing a line through this point so as to connect with the ends of the front, it is again seen to be the diameter of a semi-circle. There is still more evidence that at 8 P. M. the rear of the winds was a straight line, since reports from three stations give the time of ending of the storm at or near this time. Florence, in the northwest corner of Alabama, reports: "7:30 P. M. thunder-storm and high wind; velocity about forty miles an hour for twenty-five minutes." This would carry the time of ending to about 8 P. M. Nashville, Tenn., reports that the gale ended 7:32 P. M.,* which would place its rear at 8 P. M., a little east of that place. The observations made by S. P. Furguson at short intervals during the storm at Riddleton, located near where the Cumberland River takes a bend to the west after descending into the state from the northeast, show that the storm ended at or shortly after 8 P. M. A line drawn through these three points is very nearly straight and parallel with those obtained before. Smithville, DeKalb county, Tenn., reports: "At 9 P. M. calm." This allows the rear of the winds to be approximately determined at this time. After this no reports are given by which the rear of the winds can be determined except at Atlanta, which states that the wind ended there at midnight (local time). The other lines are drawn from the ends of the squall, as near as can be determined, parallel with the 8 P. M. line. The observation taken at Chattanooga, Tenn., at 10:08 P. M. shows that the wind averaged twenty miles per hour from the northwest during the fifteen minutes preceding the observation, but, if the line representing the rear of the high wind at 10 P. M. is correctly placed the high wind must have ended soon after. The winds within the area inclosed by these lines were mostly from some westerly quarter, but were variously reported to have blown from directions between southwest and north (by the west). Anna and Cairo, Ill., reported the gale from the northwest: Dyersburg, western Tennessee, from the west; Trenton, from the northwest; Union City, from the north-northwest, and Milan, from the north. Nashville and the stations in Middle Tennessee, south of Nashville, and in northern Georgia reported it from the northwest, with the exception of one or two which reported it from west. Riddleton, northeast of Nashville, reports the heaviest portions of the gale from southwest, and Smithville from north. Knoxville and all the stations in that portion of eastern Tennessee report the severity of the blow from the west, while stations in the southern portion of eastern Tennessee report it from the northwest. Atlanta reports it from north.

Nearly all of these reports are in accordance with the supposition that the winds blew perpendicular to the storm front at its various parts, so that in the northern part of the squall it would come from the southwest and west, in the middle from the northwest, and near the southern edge from the north. The most marked exception to this rule was at Smithville, De Kalb Co., Tenn., where

* Destructive winds do not seem to have begun at Nashville till 7:15 P. M.

the gale was reported to have come from the north. The highest velocity reached by the wind at Cairo was reported as 36 miles, at Nashville 49 miles, at Chattanooga 24 miles, at Knoxville, for an interval of fifteen minutes, at the rate of 44 miles per hour; for an interval of five minutes, at the rate of 60 miles, and at Atlanta, for intervals of fifteen minutes, 37 miles; but, in gusts, 50 miles.

The regular currents of wind seem however to have been interrupted at some of the stations by little whirls or gusts turning the vane in every direction. The following are from stations reporting it: Knoxville—"While the storm-cloud moved from west to east the wind blew from every direction, changing from west to southwest (by north) in a few minutes. The severity of the blow, however, was from west." Dickson—"At 5:45 P. M. a coperas-colored cloud suddenly appeared in the northwest accompanied by heavy wind, which was apparently a combination of whirls. In one place a heavy rail fence was thrown south, and two rods distant thrown directly north and another portion thrown east. The corn in one field would not be disturbed; in an adjoining one probably, it would be prostrated." Waverly—"On the evening of the fifth our town was visited by one of the most singular storms I ever witnessed or read of in its effects. I was sitting in my front portico watching a cloud rising in the northwest with lightning and thunder when suddenly there came a whirling gust of wind, which seemed as if it would tear up the grass and shrubbery in the yard, so closely did it hug the ground. Cucumber and melon vines were turned about and tangled up in a surprising manner. In my garden was some young corn about six inches high, which was leveled to the earth as if one had rolled a log over it. But the singular thing about the wind was its close proximity to the earth. An old dilapidated stable just back of my garden was covered with loose boards, not one of which was moved."

The accompanying observations taken at Riddleton seem to show the same phenomenon between 7:20 and 7:35 P. M. The force of the wind is given on scale of 10, 10 representing hurricane force. The following occurrence reported from there will give an idea of the force of the wind at the highest: "One man, trying to reach shelter, was caught by the storm and blown a distance of two hundred yards, and badly bruised up. Tree tops and boards of houses were carried from one hundred to four hundred yards."

Time.	Thermometer.	Wind.	
		Direction.	Force.
6:30 p. m.....	84°	S. W.	0
6:45 p. m. ...	82	S. W.	1
7:00 p. m.....	79	S. W.	4
7:05 p. m.....	73	S. W.	10
7:10 p. m.....	72	S. W.	10
7:20 p. m.....	70	N.	8
7:25 p. m.....	70	N. W.	8
7:35 p. m.....	69	W.	6
8:00 p. m.....	70	W.	4
8:30 p. m.....	71	N.	1

The observer at Sunbright, about 60 miles east of Riddleton reported that "the wind during the storm seemed to have a steady pressure from the west, with every moment a severe gust."

Observations were taken at all of the Signal Service stations at 6:08 P. M. These, with some observations taken about the same time by voluntary observers allow a more complete study of the conditions in and around the squall.

The squall was still located between the spurs of high and low pressure mentioned before. The area of rainfall accompanying it was approximately included in the area, bounded by the heavy dotted line uniting with the front of the squall

at 6 P. M. Stations just in front of the squall reported gentle winds from the southwest. Memphis, to the south of the squall, reports a wind velocity of sixteen miles per hour (the highest at any observation for three days) from the southwest or directly toward the squall. St. Louis, to the rear of the squall, reports a wind from the northwest (again directly toward the squall) with a velocity of twelve miles, this being the highest at any observation after the morning. Louisville, just to the north of the squall, reported the wind at the afternoon and evening observation from west, but at this time from northwest with a velocity of twelve miles. This seems to show that there was a force tending toward the squall acting on the air, which at Louisville was also acted on by a force tending to carry it around the cyclonic center, or from the west; but the two combined caused it to take a motion between the two, or from northwest. At the other stations mentioned the indraught action of the squall and cyclonic system was pretty much in the same line.

Cairo, which at this time was within the area of rainfall and just to the rear of the line which has been determined as the limits of the westerly gale, reports the wind from southeast, with a velocity of six miles. This shows that the winds on the opposite sides of this line, at this time, were from opposite directions. and leads to a consideration of the pressure under the squall. The pressure reported from Cairo at this time was a little higher than from any of the stations in the vicinity of the squall, the nearest approach to it being at Memphis. The observer at Nashville reports: "Barometer at 6:08 P. M. 29.895 (corrected to sea) and at 6:23 P. M. 29.983," showing a rapid rise on the arrival of the squall. This latter reading was a little higher than that reported from Cairo at 6:08 P. M., making it evident that there was an increased pressure under the squall over that of surrounding regions. The observations taken at 10:08 P. M. show the same thing. Pressure at Knoxville, 30.078; at Chattanooga, 30.050; while at Nashville, to the west of the squall, it was 30.026, and at Charlotte, N. C., to east, it was 29.95, and at Augusta and Atlanta, Ga., to the south, 30.047 and 30.050 respectively. The pressure at Knoxville was higher than at any of the stations given, though it was nearest of all to the cyclonic center, or center of low pressure, and the gradient toward Nashville on one side and toward Charlotte on the other was as great as that which usually exists in cyclonic systems. It is thus rendered evident that the squall, while preceded by a trough of low pressure and followed by rising pressure, was itself a ridge of relatively high pressure.

The area of rainfall accompanying the squall was a somewhat semicircular or oval area, though if the reports from the different stations as to the time of ending of the rainfall are to be trusted, it had an irregular outline in the rear. The dotted lines given on map II enclose approximately the area of rainfall at 5 and 6 P. M. The front of the area of rainfall, and of the winds, were closely approximate at this time, and continued so till about 7 or 8 P. M., when the front of the area of rainfall began to lag behind, and at 11 P. M. no perceptible quantity of rainfall existed within the area of high winds, if reports from two or three stations within the area are to be trusted as representing the whole. The heaviest rainfall accompanying the squall was between 5 and 7 P. M. Cairo reports a rainfall of 1.90 inch. A number of stations in West Tennessee and the western portion of Middle Tennessee reported over an inch. The average rainfall accompanying the squall in West Tennessee was about .90 in. In Middle Tennessee it was .68 in., and in East Tennessee, .47 in. There were one or two places in the northeastern portion of Middle Tennessee which reported over an inch. The observer at one of these, near Smithville, reports that "1.50 in. rain fell in forty-five minutes." Shortly after 11 P. M., the rainfall accompanying the squall had almost ceased to

exist, only one or two stations, some distance in the rear of the squall, reported that a light rainfall continued till after midnight.

Hail was reported from stations along its track in Missouri, and from one station near the Mississippi, in the northwest corner of Tennessee. After this no hail was reported except from two stations in Middle Tennessee.

In front of the squall, the temperatures were exceptionally high and air sultry, and during its passage, the stations reported a fall, varying at different ones, from 10° to 20°, with an average probably of about 15°. The fall was greatest at those stations which it passed over about the hottest part of the day, and decreased in range toward night. A fall of 22° was reported from Cairo, Ill., and Ironton, Mo., and a fall of 20° at one or two stations in West Tennessee.

The maximum temperature recorded at the Signal Office stations during the day, in advance of the squall, were 91.2° at Cairo, 93.6° at Nashville, 88.8° at Knoxville, and 86.8° at Atlanta. The minimum which were reached during the passage of the squall, were 69° at Cairo, 72° at Nasville, 65.5° at Knoxville, and 69° at Atlanta. There was generally a slight rise in temperature after the passage of the squall. The observations taken at 6:08 P. M., by the Signal Service together with one or two observations taken about the same time by voluntary observers under the squall, show that at that time there was within the squall area, a small area inclosed by the isotherm of 70°; and between this and Nashville, in front of the squall, there was a temperature gradient of 18°, between it and Memphis, to the south, a gradient of 20°, between it and St. Louis, to the rear, a gradient of 10.5°, and between it and Louisville, to the northeast, a gradient of 12°.

In regard to the extension of the cloud, its top was seen at Estill, Franklin Co. Tenn. at 4:30 P. M., rising about 30° above the western horizon. It appeared to be a white strattum of cloud matter with a fibrous fringe along its advancing edge like cirrus, extending out from but behind, merging into cirro-strattus. About 5 P. M. this fringe passed overhead, moving with unusual rapidity. After this the cloud continued to grow in density until the arrival of the squall. This observation shows that the top of the cloud extended at this time considerably over a hundred miles in advance of the squall. The observer at Knoxville reports that the zenith was clear an hour and twenty minutes before the arrival of the squall, and that the sky was obscured only to an angle of 45° all around. The top consequently could not have extended so far in advance at this time.

The following are some of the remarks concerning the appearance of the cloud, beginning with the most westerly stations and going east: Ironton, Mo.—"The cloud was inky black in the southeast." Dyersburg, Dyer Co., Tenn.—"As the storm approached the advance was a dark cloud, behind which came a deep green followed by a light green." Trenton, Gibson Co.—"The appearance of the cloud was very dark, with its edges tinged with dark green and yellow.' Centreville, Hickman Co.—"The wind-cloud, as it ascended above the horizon presented on its bosom a brilliant wide band of 'bismark' and cardinal red, this, in striking contrast to the background of the wind-cloud, which was unusually threatening, giving a magnificence to the heavens truly sublime. This bright band remained with the dark cloud until they crossed the heavens." Dickson, Dickson Co.—"At 5:45 a coperas-colored [or green] cloud suddenly appeared in the northwest accompanied by heavy wind." Knoxville—"Thunder and lightning first heard in the northwest and southwest at 8:10 P. M., at which time the zenith was perfectly clear, the horizon in every direction being covered to about 45° with heavy cumulo-stratus of a sombre gray color. A slow movement was observed from the southwest and northwest, meeting over station; their move-

ment was toward the east * * *. The thunder and lightning were terrific. Parksville, Polk Co.—"A thunder-storm from the north came up at 9 P. M., continuing until 11 P. M. This storm, as it approached, looked as if the world was on fire, the lightning being so continuous, and when it came up it seemed to be raining fire. I never saw such a continuous flash of lightning, and the wind roared in the mountains."

A green color which is often seen in hail and tornado clouds seems to be an indication of intensity of action.

The lightning was reported severe from nearly all the stations, and diffuse or sheet lightning as well as zigzag or streak lightning seems to have been a prominent phenomenon in this storm. Two mules were reported killed by lightning near Trenton, Tenn.

From a number of stations it was reported that just preceding the squall a dull roaring was heard, increasing in intensity as the squall approached. A copy of the report concerning this from Trinity, Ala., was given in the notes of the last number of this JOURNAL. A later communication from the observer, however, gives it in a rather modified form. This sound was produced by the collision of the approaching gale with the trees and other objects in the path.

It would occupy too much space to attempt to give in detail the reports from the different stations concerning the devastation committed by the storm, but the following will give an idea of this. No destruction was reported from Missouri, but in western Tennessee there seems to have been, in the track of the squall, a general prostration of the growing crops (corn, oats, etc.,) and fencing. Two or three places in this section report the timber much damaged. In middle Tennessee, especially in its northern part, the storm seems to have reached the height of its fury. Here not only were the growing crops and fences leveled, but a large amount of timber was blown down, and in the northern section the reports show that a number of houses were unroofed and a few barns completely demolished. Reports from Alabama show that this leveling of timber extended to the extreme southern edge of the squall. There was also considerable destruction in eastern Tennessee, but after the storm left Tennessee the stations are too few to determine the action of the wind. One strange thing about this phenomenon was the comparative mildness of the squall at a few stations right in the center of the track. Chattanooga, for instance, reports: "The storm of July 5th was not at all serious here, being accompanied neither by dangerous winds nor heavy rain."

The bearing of these facts on the theory of the squall will be considered in the next issue.

H. H. CLAYTON, JR.

SOLAR HEAT AND TERRESTRIAL DILATABILITY.

By SR. F. D. COVARRUBIAS.

III.—ATMOSPHERIC PRESSURES AT THE LEVEL OF THE SEA. TERRESTRIAL STRATUM OF CONSTANT TEMPERATURE.

We know that the mean height of the barometer at the level of the sea is not the same in all latitudes. This height or the pressure of the atmosphere, which it is destined to measure, changes, on the contrary, from the equator to the poles, following a law which we will express in few words. From the equator it increases in a regular manner to the latitude of 30° or 35° in the northern hemi-

sphere, and about 26° in the southern hemisphere—points where the maxima are attained; and then it diminishes toward the poles.

The explanation of this phenomenon, which has been given, up to the present, consists in supposing that the atmosphere has not everywhere the same vertical thickness. According to this theory, such a difference arises from the inequality with which the sun's heat influences the different parts of the mass of air which surrounds us. In the equatorial zone the air becomes more heated than in more elevated latitudes; and in dilating it becomes specifically lighter, which causes it to ascend toward the high regions of the atmosphere and flow toward the poles. In high latitudes the air is, on the contrary, colder; it becomes denser and is precipitated toward the lower and warmer regions of the atmosphere—that is, toward the equator. From these dilatations and contractions originates a double current, or if you please, a single continuous current, of which the higher part goes from the equator to the poles, while the lower part goes in a contrary direction. This being admitted, it is generally conceded, according to Maury and other physicists, that toward the latitude of 35° the two opposed parts of the current meet and thus produce, in the vicinity of this parallel, an accumulation of air, and consequently the real augmentation of the height of the atmosphere. In the same theory this meeting would have for cause the slow and gradual cooling of the upper current, which would make it descend little by little to the level of the lower current, and to divide in two parts, of which the one, cooler, will change its direction to return toward the equator, while the other will continue its course toward the pole.

This ingenious theory is not, in our eyes, entirely free from objections. One can not, certainly, place in doubt the existence of constant atmospheric currents which have for cause the differences of temperature, and which produce well known effects, like the phenomenon of the trade winds; but it is not so clear why the meeting of these two currents should take place at latitudes 30 or 35 rather than anywhere else, and still less why such a meeting should necessarily produce a constant accumulation of air in the same zone. It would seem more probable that the operation would be slow and imperceptible, and, if it gave rise to a maximum, it would occur in the variable region, where the temperatures of the two opposing parts of the current will balance.

But whatever be the place of their reunion, it seems difficult to us to conceive at this point the existence of a constant accumulation of gaseous matter, capable of producing a notable difference of pressure. Without doubt the tension of gases can be modified as far as may be desired, in varying their temperatures and compelling them to occupy a volume more or less considerable; but that this effect may take place, the operations must be conducted in a closed receptacle, more or less extensible, and of which the walls always oppose some resistance to the constant repulsion, with which the molecules of gas are animated. When, on the contrary, it is a question of gases, which, like the atmosphere, can extend themselves without obstruction in all directions; and when we know how difficult it is to heat gases in open vessels, and still more difficult to increase the effects of their tension, it is difficult to conceive how the atmosphere, so elastic, so mobile, so indefinite in extent, can produce in a short space, and in a constant manner the accumulation of its matter, and which, according to the conditions of the equilibrium of fluids, should resolve into new currents until the re-establishment of the equality of pressure.

The meeting of two contrary currents may often be observed in the ocean; but it may always be seen that if the shock of the waves, animated by directly opposing velocities, elevates for a moment the level of the waters, it subsides

immediately, and the reaction forms a depression in the same place where the elevation was produced. We do not know that anywhere permanent differences have been reported in the level of the sea, as compared with the surrounding ocean.

In admitting the constant accumulation of air at a given point of the atmosphere, we think it should also be produced at the equator and in the vicinity of the poles, both places of meeting of the currents. But nothing of the sort is indicated by the barometer, which signals on the contrary a decrease of atmospheric pressure in extreme latitudes.

However that may be, it is true that Maury's theory for explaining the variation of the mean pressures of the atmosphere reposes entirely upon the influence that the heat of the sun should exercise upon it. Let us examine now the same facts from the point of view of solar action upon the earth, that is, the dilatation of the surface of the soil; and we will commence by transcribing the mean barometric heights at the level of the sea in different latitudes, as given in Maury's Geography of the Sea:

LATITUDES.	NORTH.	SOUTH.	
Of 0° to 5°	759mm.84	760mm.48	
5 " 10	760 .02	761 .53	
10 " 15	761 .09	762 .71	Means of 83334.
15 " 20	762 .46	763 .52	
20 " 25	764 .06	764 .59	Observations from 50° N.
25 " 30	765 .78	764 .41	to 36° S.
30 " 35	767 .33	263 .32	
35 " 40	765 .15		
40 " 45	763 .96		
45 " 50	763 .52		

In order to render the comparison of our theory with the phenomenon with which we are occupied more striking and easy, let us construct the curve $\frac{1}{e}\cos.^2 l$, which expresses the theory, by the side of the pressures which represent the facts observed. Both have the latitudes for abscissas (in figure 4); but the ordinates of the barometric curve are counted from above down, since the atmospheric pressure should diminish when the surface of the earth rises, and the contrary. The theoretic curve is represented by a continuous line, and the barometric curve by a line of points. *N* and *S* indicate respectively the limits north and south between which the observations have been taken.

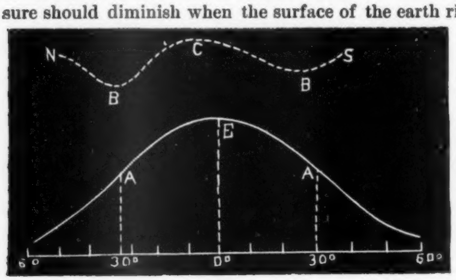


FIG. 4.

The simple inspection of this figure shows that the resemblance of the two

curves is almost perfect in all the intertropical zone. To the equatorial eminence of the first responds the minimum of atmospheric pressure of the second; and to the inflections A of the first the two maxima B of the second, which take place toward 32° in the northern hemisphere, and toward 26° in the southern, being indicated by the theory at the latitude of 30° 1′ 40″. The difference which the maxima of one hemisphere presents to the other, and, in general, the corresponding pressures in the same latitudes, depend perhaps upon the unequal distribution of land and water. the water being much more abundant in the southern hemisphere.

At the latitude of the barometric maxima the two curves begin to diverge, and this divergence extends perhaps to the poles, points where the atmospheric pressure is about the same as at the equator. Maury believes that this fact arises from the real diminution of the thickness of the atmosphere toward the poles. Some other scholars have attributed it to the great quantity of vapor of water, which they believe is contained in the atmosphere in the high latitudes, and which renders the air specifically lighter.

To our mind the first explanation is not quite satisfactory, for the low temperature of the air near the poles, the smallness of the centrifugal force, and the increase of weight in the same regions, are causes of which the combination should, it seems to us, produce the contrary effect. The second explanation seems to us more satisfactory, especially with regard to the southern hemisphere, where the evaporation must be very abundant on account of the great extent of its seas; but it certainly has less force with regard to the northern hemisphere.

Without pretending to deny all these influences, we believe, however, that there is another cause capable of contributing to the same result, and that cause is the heat of the marine currents which pass from the equator toward the poles. The best known of these currents is that of the Gulf of Mexico, or the Gulf Stream, as it is called by navigators. The heat of the water carried by this current is such that it not only improves the climate of western Europe, but it produces also a relative increase in temperature in the polar seas, of which the temperature is always higher than that of the air in the same regions. In taking for the starting point the temperature of the current, at its exit from the Gulf of Mexico, Maury calculates that the quantity of heat carried daily by the Gulf Stream and discharged into the Atlantic is sufficient to elevate the temperature of the Iron Mountains from zero to the point of fusion, and to maintain the liquid current of this metal in a volume superior to that of the water which the Mississippi discharges continually into the ocean.

Would not this additional cause of heat be capable of elevating also the temperature of the polar regions, and of producing at the same time a relative swelling, analogous to that which, according to our theory, is produced at the equator by the heat of the sun? We could not decide with regard to that; but whatever the causes of the diminution of the atmosphere's pressure toward the poles, it is none the less true that it can not be explained by the simple theory of solar heat, whether it be applied only to the earth or to the atmosphere, without admitting the existence of perturbing causes.

In effect, if instead of considering the action of the sun upon the earth, as we have until the present time, we should apply the same theory to the atmosphere, we could do it in two ways, viz., in supposing the external surface of the mass of air which surrounds the earth to be spherical, or in supposing it nearly ellipsoidal with Maury. In the first case, our function $\frac{1}{e}$ cos. l will express the law of in-

crease of atmospheric pressure, admitting at the same time that it varies inversely with the temperature of the air. The curve which results is that which we have represented by means of the line of points in figure 3, and it may be seen that they accord still less with the results of experiment, even in the vicinity of the equator, its inflections being more removed from the barometric maximum. In the second case we will find again the formula $\frac{1}{e}\cos.^3 l$, of which the divergence, compared to the pressure near the poles, we have just recognized.

It should be observed that, in the one case as in the other, we have preserved the influence of the oblique depth, e, of the atmosphere, which brings us again to suppose that the greatest part of the effect of heat is produced by the lower layers of the air. If, on the contrary, we take in the calculation $e=1$, the resulting curves will be simple sinusoids of different degrees, of which the inflections will approach nearer the poles.

The difficulty of explaining the diminution of atmospheric pressure in high latitudes by the separate action of the earth or of the air, has suggested to us the idea of examining the function $\frac{1}{e}\cos.\, l \sin.^2 l$, which expresses the difference between $\frac{1}{e}\cos.\, l$ and $\frac{1}{e}\cos.^3 l$ and supposes that the final effect is produced by the difference of action of the heat upon the atmosphere and upon the earth. This curve has inflections toward 22° 30′ and 67° 30′, and maxima toward 45°. It is represented by a continuous line in figure 5, in which the curve of observed atmospheric pressures, is also constructed; but this time we have counted these ordinates from below—upward.

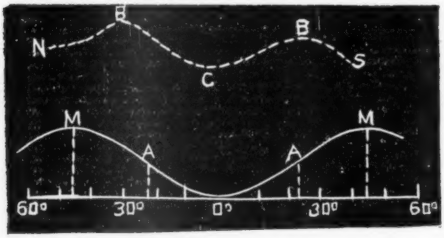


FIG. 5.

We see that these two lines have almost the same sinuosity, and that they would be very like if the pressure at the poles is the same, as at the equator, for the theoretic curve, meets also the horizontal line, for $l=90°$. Their most remarkable difference is that the maxima M of the latter are farther from the equator than those of the barometric curve. In consequence it represents less perfectly than our function $\frac{1}{e}\cos.^3 l$ the atmospheric pressure in the intertropical zone; but in the high latitudes it accords with the observations in a remarkable manner.

As a summary of these researches, we think we can establish the following propositions: 1. Without admitting the existence of perturbing causes in high latitudes neither the dilatation of the earth nor that of the atmosphere can explain of itself, and in an independent manner, the phenomenon of the variations of the mean height of the barometer at the level of the sea from the equator to the poles, whether the atmosphere is supposed to be spherical or ellipsoidal. 2. The dilatation of the earth represents this phenomenon, better than that of the air, in the first third of the quadrant, that is, in the part of the meridian where it varies more by comparison to the variations of latitude. 3. In supposing the atmosphere nearly spherical, the differential action of the earth and the air accords well enough with the whole of the observed facts.

We believe ourselves authorized to deduce from these propositions the general conclusion that the dilatation of the earth is not imperceptible, and that, on the contrary, it seems to co-operate effectually in the production of the phenomena which we have considered.

But the influence of solar heat upon the figure of the earth manifests itself, to our mind, by another phenomenon not less worthy of attention. We know that at a greater or less depth, but always small, below the surface of the soil, we find everywhere a stratum of which the temperature is constant for every place, and almost equal to, or very little greater, than the mean temperature of the air in the same place. It is designated by the name of invariable stratum, and it is at its surface that the thermometric manifestations of the oscillations of external heat cease, and at which the temperature begins to augment in proportion as the depth increases.

We do not possess, up to this time, sufficiently numerous observations to be able to assign exactly the general form of this layer; but we know that, very superficial at the equator and in nearly all the intertropical regions, where its depth is seldom greater than one *metre* below the soil it becomes deeper in the temperate latitudes.*

It is principally in laying stress upon the two characteristic properties of the invariable stratum, that is, its slight depth below the soil and its temperature which is not influenced by the variations of external heat, that physicists have established the fact of the feeble conductibility of the terrestrial strata. Perhaps these same properties are also those which have led them to admit that the soil is not dilatable, since the elevation of the temperature and the increase of the volume are two phenomena, which we are in the habit of seeing produced together, and which spring from the same cause, the action of heat.

We believe, however, that the third equally characteristic property of the invariable stratum, that is, that of having everywhere a temperature very little greater than the mean of the air in each locality, can be explained only by the action of solar heat. In effect, if this property were only the result of the original heat of the earth, called central heat, we could find, according to the laws of the propagation of heat, that the temperature of the soil would be the same for the same distances from the center of action. Thus, for example, the temperature of the invariable stratum at the poles would be found again at a depth of about 21 kilometres below the soil in the regions near the equator, because that is the difference of length between the polar and equatorial radii. In other words, the temperature of that stratum at the equator should be less than that at the poles, which is quite contrary to the results of observation.

It must be admitted that it is principally the sun which produces these constant temperatures at each point of the invariable stratum, and that they constitute, so to speak, the material manifestations of the mean quantity of heat which each place on the earth receives from the sun, according to its position in relation to the equator.

There is, in consequence, the effect of a continual action, which propagates itself to a great depth, which maintains in the strata of the globe a determined

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* At the City of Mexico, of which the latitude is about 19° 26′ 12″, the observations of the temperature of the soil are taken at a depth of $0^{m}.85$, and, as we remember, the extreme oscillations of the thermometer do not reach 5° in the course of a year, the diurnal oscillations being almost imperceptible. We believe that the depth of the invariable stratum below the surface should not be greater than about 2 *metres*, in spite of the great altitude of the city, which is 2,260 *metres* above the level of the sea.

At Paris it is found at a depth of 27 or 28 *metres*, and it seems, according to the observations of MM. Erman and Schergin, which were made in Siberia at 62° of latitude, that it becomes superficial in the high latitudes.

degree of heat, and which, perhaps, combines farther on with the action of the central heat of the earth.

Now the simple fact that these temperatures change with the latitudes, following a certain law of decrease, will conduct us to the conclusion that the same law should concur in regulating the intensities with which the phenomenon of dilatability is produced, whatever may be the smallness of the coefficients of dilatation of the substances which compose the soil.

The action of solar heat is, in consequence, the determinate cause of a phenomenon modifying the figure of the earth.

But, in our opinion, this permanent state of dilatation, of which the intensity decreases from the equator to the poles, is not the only effect of this kind produced by the sun. We believe, at the same time, that this mean state is continually modified by the influence of solar heat, notwithstanding the feeble conductibility of the soil; and that, if the oscillations of external temperature do not produce variations in the indications of the thermometer at a short distance below the surface, the same thing may not occur with regard to the other manifestation of heat, that is, the work of internal motion. In hazarding this hypothesis we are obliged to give, though briefly, the reasons which seem to support us.

According to the dynamic theory of heat, supported to-day by an infinity of facts, "the caloric movement communicated to a body resolves itself: first, in heating or heat perceptible to a thermometer, it is communicated heat; second, in internal work, or the separation of molecules, it is transformed heat, imperceptible to the thermometer; third, in external work, or action against external resistance, it is also transformed heat." *

In solid bodies, generally very slightly dilatable, the second portion of heat-action, that is, that which transformed into internal work, produces molecular separation or dilatation, is perhaps the most important, at least when the third portion, destined to overcome external resistances, meets only that of atmospheric pressure. It is, in our opinion, the case with the earth; and when we reflect on the immense quantity of heat which its hemisphere lighted by the sun receives; when we know the feeble effect of that heat upon the lower strata of the atmosphere, the constancy of a low temperature in the upper strata, the small distance below the surface at which it is revealed by the thermometer; and when we wish to account for the very remarkable fact that the region which receives the most heat is precisely that in which the invariable stratum is found at the least distance below the earth's surface, we believe that it is not possible to think otherwise than that the greater part of the heat which is received is absorbed by the earth in the form of molecular movement, and that it penetrates far enough to produce the expansion, the curve, or the swelling of the superficial strata of the globe.

In the last result our hypothesis returns to admit a certain order of succession, of intensity or of extent, between the two effects of heat, between the dilatation and the heating, since we know that the first makes itself felt at a greater distance than the second, without being necessarily accompanied by it. It is true that, in most cases, the phenomena due to the influence of heat, manifest themselves together; but have we, up to the present time, the means to appreciate singly the action, the intensity and the extent of each one? Do we even know the relative quantities of heat of which they have need for their production? Is it not true

* We borrow these lines from the *Traite du Physique* of M. Ganot, for we could not give in a shorter, clearer manner the effects of heat, according to the thermodynamic or movement doctrine.

that in most bodies the dilatation is not vigorously proportional to the heat? Have we the right, then, to admit only the necessarily simultaneous production of these two phenomena and the constancy of its ratio to their intensity? According to thermodynamics, is heat anything but the manifestation of a special form of molecular movement? And if it is a motion, the dilatation is also a movement which, in our opinion, prepares, and consequently precedes the other.

Science offers, besides, examples where the manifestations of the two phenomena, far from being simultaneous, present themselves, on the contrary, entirely isolated. During the fusion of bodies and during their vaporization their temperatures do not rise, and all the heat which they receive is employed in the production of motion, in the great internal work of molecular disagregation, that is, in a veritable dilatation, which has reached a great degree of intensity. If it is only then that it is perceived that dilatation is the only phenomenon which is produced, it depends on the instruments possessed for measuring separately the progress of the heating which becomes really null at the moment when the bodies change condition; and there are no means of measuring the progress of the dilatation, but, it is natural to believe that, since the first of these movements is directed toward a minimum, and the second toward a maximum, they should have a progression very different before the fusion or the vaporization, and, up to a certain point, opposite as to intensity. Now, is dilatation in general, of which the effect is that of removing one from the other the molecules of matter, anything, at the bottom, but a commencement of fusion for solids and of vaporization for liquids? Why, then, not admit, during the progress of that fusion or of that vaporization, a different progress of the two causes which determine the phenomena, and which we see really separated at the moment of their complete accomplishment?

But if these reasons do not seem sufficient to authorize our hypothesis, we will mention another phenomenon which comes to its support. It is during the absence of the sun that the cooling of the earth takes place with the greatest intensity; and we know that during the night the soil becomes so cold that, even in the intertropical regions, its temperature is generally lower than that of the air, just before daylight.

In casting the eyes upon the comparative observations which we inserted at the close of our last section, it will be seen that at seven o'clock in the morning this difference of temperature has been more than 4° during the last winter at Mexico.

The soil only warms up during the day to a very small depth; from whence comes then the enormous quantity of heat that the earth sends into space across the diathermal mass of the atmosphere, which is capable of cooling the soil itself, in spite of its feeble conductibility? Is it entirely in the air? Certainly not, since its extreme limits of temperature are less than those of the surface of the soil, and that its great dilatability requires comparatively little heat. Ought we not to believe that it has been absorbed, in great part, by the earth under the form of motion, and is consequently imperceptible to the thermometer?

Such are the principal foundations of the hypothesis that we have dared to propose, which we see in accord with thermodynamic theories, and without any opposition in regard to the best established scientific facts. In waiting for new experiments to confirm or to overthrow it, we admit in the earth, not only a permanent state of dilatation of which the intensity changes with the latitude, because of the constant action of the sun which originates it, but also the intermittent modifications of this mean state, of which some will be produced by

changes of position of the sun in the different seasons, and the others by its variable and intermittent action during the course of the day and night. The first modifications will explain the maxima and minima of mean atmospheric pressures, which, as we know, happen respectively in the coldest and the warmest months of the year, that is, in the epochs where, according to our theory, the surface of the earth, for each place, should be respectively more contracted and more dilated. The second modifications will give the explanation of the regular diurnal oscillations of the same atmospheric pressure, which have not been explained up to this time, except in a vague and imperfect manner by the variations of temperature of the air; and that thus, as may be seen in the following section, we have succeeded in connecting, by means of our theory, by a general law applicable to all latitudes. But, before leaving this section, let us examine the invariable stratum from the point of view of the depths at which it may be found in different latitudes. If, according to the law of Newton, the radiation of heat from the earth is proportional to the excess of heat at each point, it will be represented by our function $\frac{1}{e}\cos. l$, since it expresses the relative heat that they receive; and we deduce from it that in the same ratio would be found the quantities of heat really absorbed by the earth. But those employed to produce its dilatation being proportional to $\frac{1}{e}\cos.^2 l$, the difference $\frac{1}{e}\cos. l \sin.^2 l$ of the two functions will express the quantities of heat remaining or free. This difference is graphically represented by our curve of figure 5, which has minima at 0° and at 90° and maxima toward 45° of latitude.

Let us see now if the facts accord with these indications of the theory, and, for this purpose, let us stop an instant upon the observations which are known to us of the slightly different depths of the invariable stratum. At Popayan, Quito and other places near the equator, generally very high above the level of the sea, M. Boussingault found the invariable stratum at about $0^m.5$. At Paris, in the latitude 48° 50′, it is at 28^m, its constant temperature being 11°.8, or a degree higher than the mean 10°.8 of the air.*

Finally, from the observations of MM. Erman and Schergin, made at different depths at 62° of latitude, we conclude that the temperature of −8°.7 (also a degree higher than the air) may be found at about 7^m below the surface of the soil.

These numbers seem to indicate maxima and minima of depth, toward the same points where the curve indicates the maxima and minima of free heat. Such a coincidence leads us to think that these quantities of heat, penetrating more deeply into the earth, could produce abnormal dilatations of the soil, or irregular heating of the air. They will serve, perhaps, to explain, at least in part, the disturbances of the equilibrium of the ocean and of the atmosphere, which are so frequent in the mean latitudes.

(*To be concluded.*)

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* According to the complete observations, the mean temperature of the air at the equator is 27°.5 at the level of the sea. Our theory would make it $\frac{27.5}{e}\cos. l$ or very nearly, $27.5 \cos.^2 l$ for the latitude l; and its formulæ, applied to the latitude of Paris, give 11°.9, which is nearly the temperature of the invariable stratum, and a little more than the mean of the air.

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—EDITED BY—

M. W. HARRINGTON,

Director of the Astronomical Observatory, Ann Arbor, Michigan.

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The Editor does not hold himself responsible for any matter in the JOURNAL which is signed by either full names or initials.

LITERARY NOTES.

—From the September *Bulletin* we learn that the Nebraska Weather Service has now 45 stations, covering the state as far west as North Platte and Red Willow. The bulletin includes, and will hereafter include, simple explanations of instruments and proeesses which will doubtless be welcome to the observers.

—The *Elisha Mitchell Scientific Society* of Chapel Hill, N. C., has just issued its first *Annual Journal* which shows considerable scientific activity. The Journal contains many things of scientific interest, among which we may mention accounts of the tornadoes of February 19 and March 25 of this year, of the storm of April 22, 1883, and of the fall of blood at Chatham on Feb. 25, 1884. The last is a mysterious phenomenon, the chemical aspects of which have been carefully studied by Dr. Venable, the professor of chemistry at Chapel Hill and president of the society. Professor Gore gives a brief theory of tornadoes in which we recognize, under a new dress, the long known conflicting-currents theory.

—In the October *Sidereal Messenger* Mr. J. R. Hooper of Baltimore publishes some notes on the recent peculiar atmospheric conditions. He finds that during the red sunsets the sun was easier to observe (telescopically) while the stars suffered much. In both cases it was undoubtedly the result of obscuration, and this was probably due to the matters suspended in the air.

—The current *Report of the Minnesota State Horticultural Society*, contains somethings of meteorological interest. Col. S. D. Robertson, the veteran Minnesota meteorologist, has various climatological studies and Mr. A. W. Sias has a brief article on tornadoes, which has a very strong arboricultural bias. We have elsewhere (p. 74) commented on Prof. C. W. Hall's lecture on the "Physiographic Conditions of Minnesota Agriculture."

—The *Annual Report of the Ohio Meteorological Bureau* for the year beginning Nov. 1, 1882 is at hand. It is a pamphlet of 125 pages with many graphic representations of the *gait* of the meteorological elements at each station in addition to the usual summaries. In it is also a paper on the floods of the Ohio River by Dr. Dun of Cincinnati. This is the best discussion of the subject that we have seen. The Bureau has accomplished very much with the small appropriation given it. We note with pleasure that the appropriation was somewhat larger the second year.

—We have received from T. B. Helm of Logansport, Indiana, copies of the *monthly reports of the weather* published in the *Weekly Journal* of that place. We are interested in the flood of February, 1883, his account of which brings into unusually clear view the necessary conditions of a winter flood. They are frozen ground with heavy snow followed quickly by unseasonably warm weather and rain. The frozen ground prevents the rapidly accumulating water, resulting from precipitation and melting, from being absorbed; the water flows off from the impervious ground as from a roof, and the flood results. The following is Mr. Helm's account:

Introductory and incident to the flood of the 3d and 4th ultimo, heavy snow flakes began to fall about 10 o'clock a. m. on the 2d, with a temperature ranging from 10° to 19°, and continued irregularly until 8 o'clock p. m., when rain began to fall in inconsiderable quantities during the early part of the night. About 11 o'clock p. m. there was some heavy thunder and sharp lightning in the southeast, followed by a mixture of rain and snow, which, a little later, were transformed into sleeting rain. This character of precipitation was continuous and profuse, the aggregate quantity of rain being 2,350 inches, at 6 o'clock p. m. of the 3d. The snow upon the ground was encrusted with ice, and trees of all classes, especially fruit and shade trees, and shrubbery were covered with the heaviest coating of sleet ever known in this vicinity. Fruit and shade trees suffered seriously from the unusual weight, great numbers of both being crushed to the ground and destroyed. The flooding rains which appear to have been general, augmented by the melted snow, produced a flow of water almost unprecedented. In the rivers the flood reached a height above that of August 2, 1875, and about equal to that of January 1, 1847. By the sudden rise, the ice, which was not very heavy, was forced down the channels, causing less damage here than might have been reasonably anticipated. From the 13th to the 16th there was another heavy rain-fall from which the rivers were again surcharged with water, but occasioned less damage than before.

—Professor S. P. Langley has recently published an important paper in the *Am. Journal of Science* on the amount of the atmospheric absorption of light and heat. His general conclusions are that the absorption is of a much more complex character than has heretofore been assumed, and that the quantity of radiations absorbed is at least double the figures heretofore adopted. One sentence of the paper is so striking that we transcribe it. On p. 17 of the reprint the author says: "Almost all the phenomena of meteorology would become predictable if we knew how much heat reaches the soil, and how much, and in what altered kind, is returned to outer space."

—The August number of the *Monthly Weather Review* has, for the first time, the name of the official in charge of its compilation. Lieut. W. A. Glassford is credited with this number and concurrently appear several improvements. The most noticeable are two additional charts. The first represents the relation of the Michigan frost of Aug. 9 to the isotherms of that day; also the same relations for the New York and New England frost of Aug. 25. The second chart shows the departures from normal of the atmospheric pressures and temperatures for August. Both charts are instructive. This number also contains several more pages than the preceding. The notes on the earthquake of Aug. 10 are the most complete we have seen. We note that Professor H. A. Hazen reports the mean distance and direction from the nearest "low" of the 900 thunder-storms of the month as 515 miles and a very little west of south. The red sunsets again attracted much attention.

—The monthly *Weather Review of the Canadian Meteorological Service* appears with commendable regularity, and the August number lies before us. It derives its data from a very large number of observers from Prince Edward's Island to Manitoba. Its general character is that of the corresponding publication of the Signal Service but it contains also the summary by hours of sunshine at 14 stations and a condensation of the magnetic observations at Toronto. The hourly frequency of the winds from the eight principal points is represented graphically in a neat manner. Charles Carpmael, Esq., is the superintendent.

—To the old problem of *differences of rainfall with elevation* we have two recent American contributions. Mr. G. E. Curtis' contribution makes Signal Service Notes No. XVI, and is entitled "The Effect of Wind-Currents on Rainfall." It is a careful study of the subject, and includes some account of previous work in the same line. Elaborate observations on the subject have been taken on the top of Mt. Washington, and the most important of the results may be thus expressed: 1st. With gauges of the same size the amount of rain collected depends on the relative windward or leeward positions of the gauges, the windward gauges getting less precipitation. 2nd. With gauges of different sizes, the more rain is collected by the larger gauge, and the ratio between amount collected by the larger and smaller increases with the square of the velocity of the wind. The formula obtained by Mr. Curtis for two gauges 8 and 3 inches in diameter was,

$$\frac{G_8}{G_3}=1+.015\psi^2$$

where G_8 and G_3 represent the collection for the 8-inch and 3-inch gauges and ψ the velocity of the wind.

The second study is that of Mr. Desmond Fitzgerald. It is published in the *Journal of the Association of Engineering Societies* for August, 1884, and also relates to the effects of wind on rainfall. The observations were taken at Chestnut Hill Reservoir in Boston. The article is illustrated by profiles and shows a careful study. The general conclusion is that there is no distinct law of agreement between wind-velocities and the ratio of rain collected in two gauges at a difference of elevation of 17 ft. 10 in. Mr. Fitzgerald does not seem to have taken into account the windward or leeward position of his elevated gauge with reference to surroundings. That, in view of the simultaneous publication of Mr. Curtis, may be seen to be a serious defect. The problem involved is a double one; Mr. Curtis has taken into account both elements, Mr. Fitzgerald but one.

CORRESPONDENCE.

TWILIGHT PHENOMENA.

To the Editor:—That the phenomenon described by Mr. Bartlett in the October number of this Journal was nothing more than a fine example of our red sunsets his own description plainly proves. As the zodiacal light has an apparent diurnal motion (being practically fixed with reference to the stars) and always lies along the ecliptic, and as the meridian distance of the ecliptic at the time of observation was more than 60°, the query, whether the phenomenon observed might not in some way be connected with the zodiacal light, seems to be uncalled for. The same may be said of M. Bartlett's concluding remarks, "I can think of no explanation for a phenomenon so startling and mysterious, unless it be attributed to the same unknown cause that produces the zodiacal

light, and in which the solar corona may possibly have its origin."

Now, while there are differences of opinion as to the nature of the matter causing the colored appearance of the sky, nearly all of the observed phenomena, Mr. Bartlett's not excepted, can be satisfactorily explained by assuming that the particles reflecting the light are situated in our upper atmosphere and, for a given locality, pretty uniformly distributed in horizontal layers. After the sun has disappeared below the horizon, and the refracted rays no longer strike the matter suspended in the atmosphere in the immediate neighborhood of the observer, the phenomena of the upper atmosphere are revealed. If there are no clouds in the direction of the sun, within two or three hundred miles of the observer, the illumination will appear to be continuous, gradually fading away as the angular distance from the sun increases. If, however, clouds are present, although lying below the observer's horizon, their distance and height may evidently be such as to wholly cut off all rays which would otherwise pass through an upper stratum of the atmosphere, above the horizon of the observer. Dark bands, apparently radiating from the place occupied by the sun and crossing the illuminated sky, would be produced. Similarly a great bank of clouds, having gaps here and there, allowing beams of light to pass through, would cause illuminated bands against a blue or dark background. In this way the phenomena observed by H. H. C. are explained. Having given the distance and height of one of these clouds, or gaps, and the position of the sun, the average height of the reflecting particles can be determined, provided the law of atmospheric refraction is assumed to be known.

In answer to the query proposed by Dr. Murrell in the September number of this JOURNAL, the following explanation is offered. The earth's atmosphere, acting as a lens, both refracts and disperses the light of the sun. The blue rays being most refracted, will leave the earth's atmosphere at a greater angular distance from the sun than the red rays. The layers of atmosphere containing the suspended matter will therefore vary in color as the angular distance from the sun increases, red being nearest to the sun *so long as the illumination is a direct one.* As seen from the upper limit of the atmosphere, the vertical diameter of the setting sun would appear to be but little more than one-half of the horizontal diameter. The upper edge would appear red, the lower edge blue. The same colors should show (theoretically), in a less degree, at the earth's surface.

J. M. SCHAEBERLE.

ANN ARBOR, Oct. 4, 1884.

P. S.—Last evening I was so fortunate as to obtain data by means of which the height of the matter reflecting the light can be determined with a considerable degree of accuracy.

At 5:38 the illumination in the western sky was of moderate brightness, at the same time the eastern horizon, from N. 45° E. to E. 30° S., appeared (as usual in case of a red sunset) quite red up to an altitude of 30°. I was hardly prepared for the sudden change in the view which was presented at 5:40. The light which, two minutes before, was spread mostly along the horizon, now appeared to radiate from the circumference of a semicircle, having a diameter of about 15°, in the form of red rays or bands from 5° to 15° in length (all lying above a horizontal line drawn through the center of the circle), plainly showing that the illumination was a direct one, and *not* a reflection from the western sky. The interior of this circle was not illuminated. The co-ordinates of the center were roughly estimated as follows: Altitude=20°, Azimuth N. 85° E. The duration of this phenomenon was certainly less than three minutes, for at 5:43 the whole eastern sky was of its usual bluish tinge.

Assuming that the matter in the east was illuminated by those solar rays which were nearly tangent to the earth's surface,

hen, as the line of intersection of these rays with a layer of atmosphere containing the suspended matter would, in prespective, appear as an arc of small circle, the given data fixes the height of the layers in question at only four miles. The above phenomenon should be looked for, it appears, when the sun is about three degrees below the horizon.

October 7, 1884. S.

To the Editor:—I am very much interested just now in the process of recording magnetic and meteorological phenomena by photography. I find that all the information I have leads to the belief that uniformly good records, clear, sharp and distinct, are not produced uniformly by anybody during long intervals. The only places in North America where photographic registration of magnetic or meteorological phenomena is now carried on, that I know of, are:

1st. Toronto, Canada—has in operation a magnetograph, barograph and thermograph.

2d. Los. Angelos, Cal.—has in operation a magnetograph.

3d. Baltimore, Md., (Johns-Hopkins Univ.)—has in operation an electrograph." (?) Variations of atmospheric electricity are photographically recorded —instrument used, a Mascart's electrometer.

A complete list of all in North America or in the world would be of interest.

Oct. 17, 1884. B.

[Should there be others in America, we trust our readers will inform us.—Ed.]

PUBLISHERS' DEPARTMENT.

Owing to an unlooked for demand for the June, July and October issues of this Journal, the supply has become nearly exhausted, and the publishers will pay twenty-five cents for each and every copy of these numbers and be especially obliged to the senders as well.

The circulation of this Journal has increased upwards of thirty per cent. during the past six weeks. The American Meteorological Journal has a circulation not often secured in the first six months' history of new periodicals, and this is steadily and surely increasing.

A number of errors crept into Mr. G. K. Gilbert's article in the September issue of this Journal, of which the proper corrections appear in this number. These errors, which could not be more annoying to the author than they were to the publishers, were occasioned by circumstances rather than carelessness in proof-reading. These circumstances rendered it necessary that the September issue should be out of the press before a certain date, and, owing to Mr. Gilbert's absence from home, the corrected proof was not returned in time to be used—hence the errors in the formulæ. As annoying as they were, they seemed unavoidable, and were not due to carelessness. Great care is taken to make the pages of the Journal accurate—typographically and otherwise.

CORRECTIONS.

To the Editor:—Owing to my absence from home, the September number of the Journal has not fallen under my eye until to-day. There reached me, however, some separately printed copies of my contribution to the number, and I noted a typographic error, to which you were so kind as to call attention in the October number. I now find that there are numerous discrepancies between my separate copies and the article as published, and that the article involves errors of a more serious character than the one originally detected. To render the discussion intelligible and consistent it is necessary to make the following corrections:

On page 169, in the numerator of the second member of equation (3), substitute $cs-op$ for "$c-e$."

In line 13, for "coincidence of $o+p$," read: coincidence of o and p.

On page 170, line 9, for "function of e," read: function of s.

In line 10, insert a dash after "occurrences."

In line 25, insert a comma after the words "of o."

In line 29, for "c and p," read: o and p.

On page 171, line 17, *dele* comma after "twice."

In line 22, transpose comma, so as to read: values of o', p' and c',

In line 23, change "=" to + in the denominator of the fraction.

Very respectfully,

G. K. Gilbert.

Washington, Oct. 15, 1884.